OIL, GAS & PETROCHEMICAL PROCESSING

Petroleum Refiner

MARCH
1958

PIPING SPECIAL REPORT

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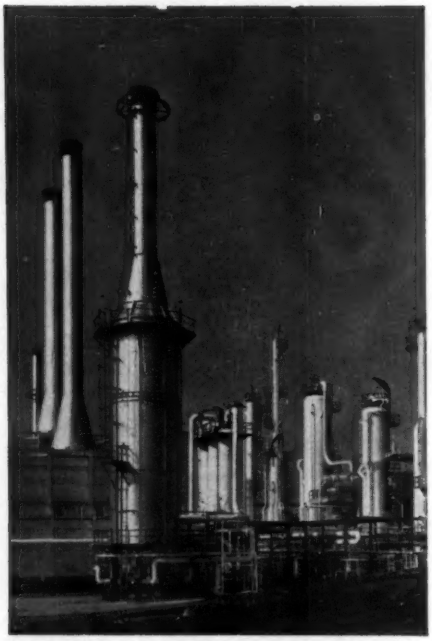

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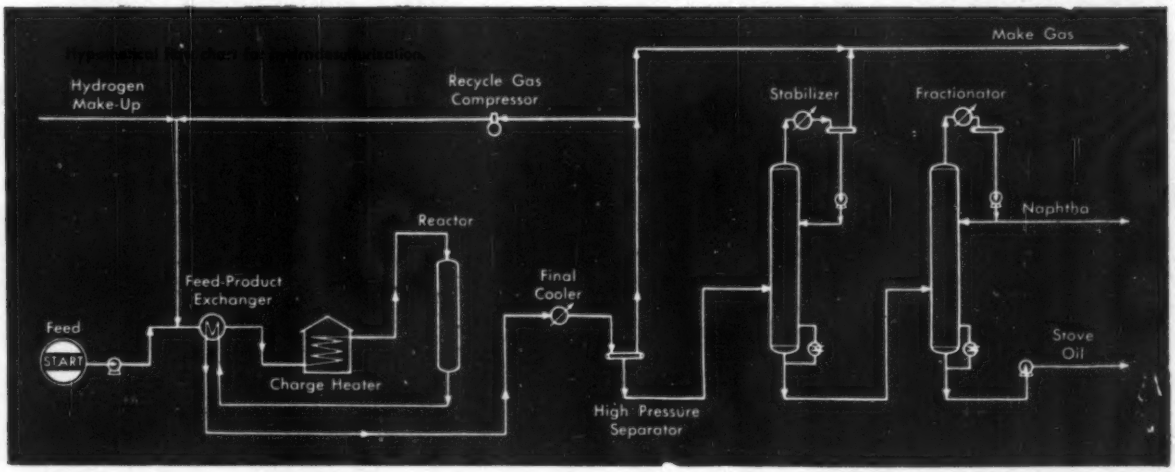

Since you know the critical ingredient of any catalytic hydrogenation reaction is the *catalyst*, the above facts should prompt you to acquire complete details on this premium commodity in the field of catalytic hydrogenation. We shall be happy to point out the many specific advantages that come with using Harshaw Cobalt Molybdate Catalyst and discuss any specific application you may be considering.

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Volume 37, No. 3 March, 1958

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Petroleum Refiner
OIL, GAS AND PETROCHEMICAL PROCESSING

A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

SPECIAL REPORT ON PIPING

☐ **How to Design Tower Piping . . .** Good piping design has the hallmark of simplicity. This method will save time and money. Since piping is half the cost of a process unit, it deserves special attention. For tower piping design check list, turn to **Page 136.**

☐ **More Piping PSI for Your Dollar . . .** The cheapest or the strongest piping material is not necessarily the most economical. Here is a tabulation of allowable "S" divided by the relative cost of all Code materials which quickly permits you to select the most PSI your dollar can buy. Turn to **Page 143.**

☐ **How to Estimate Piping Labor . . .** Labor units are the essential tools of any estimator. Using a flow sheet, piping specifications, plot plan or other piping drawings, and bill-of-materials along with these labor units, you can quickly estimate the piping labor for any particular job. Clip this time-saver now, turn to **Page 147.**

☐ **Save on Pipe Support Foundations . . .** Here's a method, adaptable to machine computation, for designing the most economical pipe support foundation. Based on standardization, you can easily adapt it as a short-cut for one of your most routine tasks. Turn to **Page 150.**

☐ **Tips for High-Pressure Piping . . .** Here's a brief summary of points which must be considered in designing high-pressure piping systems. Plant layout, construction and testing procedures are discussed. Although somewhat conservative, these methods are must reading for those in high-pressure processing. Add this to your design file. Turn to **Page 155.**

☐ **New Agitator Absorber for CO_2 . . .** You can get more efficient CO_2 removal in this agitator absorber than with conventional equipment. The inherent advantages of increasing amine strength cause

Please Turn Page ➔

none of the usual operating problems. An equation is given for calculating operating conditions directly. Compare your present equipment with these data, turn to **Page 163.**

☐ **Newest Acetylene Process from Japan . . .** Offering advantages over present partial oxidation processes, this new acetylene process gives good yields from a variety of hydrocarbon feed stocks. Based primarily on methane, acceptable yields are obtained even from butane. Operating variables are discussed for several raw materials. Study this before any new acetylene venture. **Page 169.**

☐ **Predicting Convergence Pressure . . .** Equilibrium ratios can be predicted quickly and accurately by the use of convergence pressure as a correlating parameter. Here are simple-to-use procedures for predicting convergence pressure. They apply to a wide range of temperatures and components, including paraffins, olefins, naphthenes, aromatics and nonhydrocarbons commonly occuring in hydrocarbon mixtures. This is a must for your process design notebook. See **Page 173.**

☐ **Applied Hydrocarbon Thermodynamics (Part 3) . . .** This part of Edmister's series deals with liquid and vapor densities, and covers the P-V-T properties of eight light hydrocarbons. For the very latest data on these properties be sure to look on **Page 183.**

☐ **Cathodic Protection May Boost Corrosion!...** In the case of non-ferrous alloys, service results show that cathodic protection could be detrimental to exchanger tubes. The protection prevents formation of a natural film on the tube and subjects it to impingement attack. For complete details, turn to **Page 189.**

☐ **How Much Mixing Occurs in a Pipe? . . .** If you are using one line to handle a variety of materials, you may want to know how much one material contaminates the preceeding one. Here are a number of charts which permit you to figure this easily. All you need to know is the Reynolds number and the pipe dimensions. **Page 191.**

☐ **Measure Vapor Losses with Radioisotopes...** Here is a method for determining the quantity of vapor losses from enclosed spaces such as oil-water separators. Krypton-85 was used as the radiotracer. Here is a method which you can apply to your pollution problems. Turn to **Page 195.**

☐ **Better Yields After Nitrogen Removal . . .** Here are data to show the effects of nitrogen on yields from catalytic cracking. To see how much improvement you can expect from nitrogen removal, turn to **Page 197.**

☐ **Plan Before You Start Experimenting . . .** Your data will be more valuable to you if you plan your runs beforehand. In order to understand most systems, you must perform experiments capable of determining how factors operate jointly to influence the system. This discussion tells some of the pitfalls encountered when only one variable is changed at a time. Turn to **Page 201.**

☐ **Figure Flash Equilibrium Quicker . . .** If it seems you always make bad guesses on trial-and-error calculations, try this new method on your next multicomponent flash problem. It requires only a few more steps, but it gives you the answer much faster. **Page 209.**

☐ **Bolted Clean-Out Doors for Your Tanks . . .** In the past, tank access openings have been either riveted door plates or manway-type openings with bolted covers. A new look in clean-out doors has just been developed with a bolted door that will not leak and is safe from stress. For complete details, turn to **Page 213.**

☐ **Design Tips for Your Motor Circuits (Part 1) . . .** A typical refinery unit's motor circuit system will be designed, step by step, citing the National Electrical Code rule that applies. The article illustrates how each item in the circuit should be selected. For complete details, turn to **Page 219.**

☐ **Instrument Panels Made for Easier Operation . . .** With the ever growing tendency to get and record more data about a process unit, control panels are becoming too large and confusing for easy operation. Here is a plea for more simplified presentation of data for the operator. Turn to **Page 224.**

☐ **Do You Motivate Safety Habits? . . .** Many refineries are missing out on an excellent way to reduce accidents. That method is motivation of safety habits. Here is the plan and a detailed description of how it can work for you. Turn to **Page 257.**

☐ **What You Should Know About Refinery Contracts . . .** What is an "express" contract? What types of contracts must be written to be enforceable? What requirements must be met for a contract to be valid? These are just a few of the questions which might arise in an average refinery operation—yet few refinery executives know the answers. You can find the answer to these questions, plus many others concerning contract law on **Page 259.**

☐ **How Well Do You Handle New Employes? . . .** Studies show that engineers usually change jobs within the first year or two after joining a company. The same studies show that well-planned orientation will help reduce engineers' migratory tendencies. For complete details on an orientation program that will fit into any refinery operation, turn to **Page 266.**

☐ **You Can't Live Forever . . . But . . .** In this busy word health isn't given much consideration until a person loses it. Whether you are in the business or operation end of the oil industry, you will benefit from these 10 excellent ways to a longer and more enjoyable life. Turn to **Page 280.**

Petroleum Refiner

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PETROLEUM REFINER and The REFINERY CATALOG for the refining, natural gasoline, petrochemical industry.

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IN ORDER TO CONTINUE as second to none in its field PETROLEUM REFINER must fulfill its aspiration of being the *most* useful of any periodical seeking to serve the petroleum processing industry.

Our editors keep this point constantly in mind and —thank Heaven for them—our readers via a continuing flow of ideas and suggestions help us attain the goal from month to month. No reader interest survey, general or special, is ever undertaken that doesn't include space for the reader to let us know how we can be more helpful to him in his work.

Just useful isn't enough for PR. We want to be *most* useful.

All of which leads us to the point of repeating an ever-standing invitation: If you think of something that you believe would be useful in your work and the work of others in your category, why not drop us a note? We always try to be alert to our readers' needs and, this is for sure, their suggestions get the fullest study and consideration.

Chance To Back Up

NOW AND THEN we get a phone call or a letter inquiring about PR's Annual Editorial Index. That's an easy one to answer:

This annual index appears as a section in the December issue each year. PR dated December, 1957, for example, carried the 1957 index as an 8-page section facing Page 164.

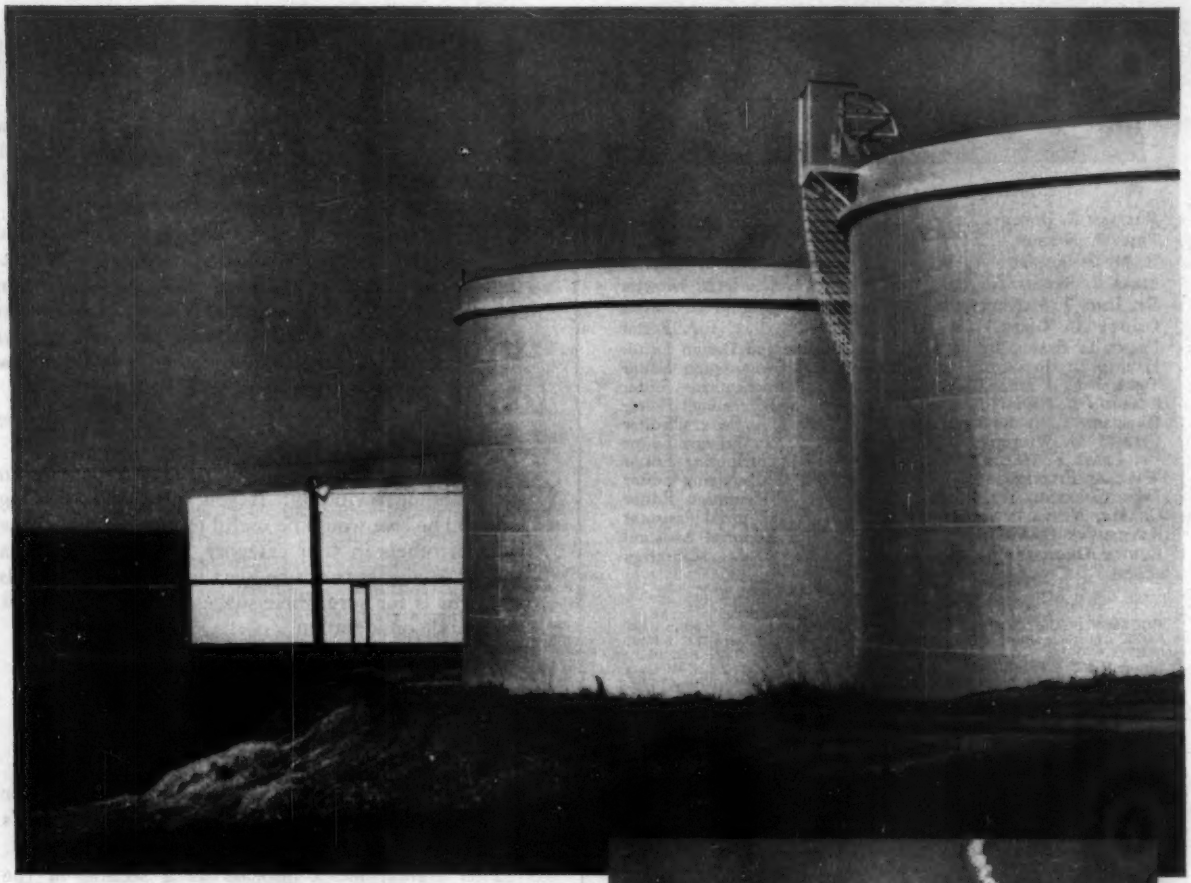
This identical index is available as a *separate* for those who want it in that form. Just request it of our Librarian (PETROLEUM REFINER, Box 2608, Houston 1, Texas) or, if you prefer, use the Reader's Service card in the back of every issue of PR. Just write "1957 Index" across its face and drop it in the mail.

From The Fine Print

OUR PUBLICATION DATE is the 12th of each month.

Sometimes a reader will complain about late receipt of his copy before the postal boys actually have had a fair chance of effecting delivery. That leads us to believe that maybe some of you have never noticed —in small print to the left—that the 12th is our target date. Many periodicals issue on the 1st of each month and maybe that's a confusing factor.

Also, the publication date doesn't necessarily mean that all copies are mailed that day. The first copies of PR come off the press—or at least that's what we shoot for—with the actual mailing the next day afterward. Before a new wrapping-addressing machine was installed last month it took two to three days for the actual mailing process.



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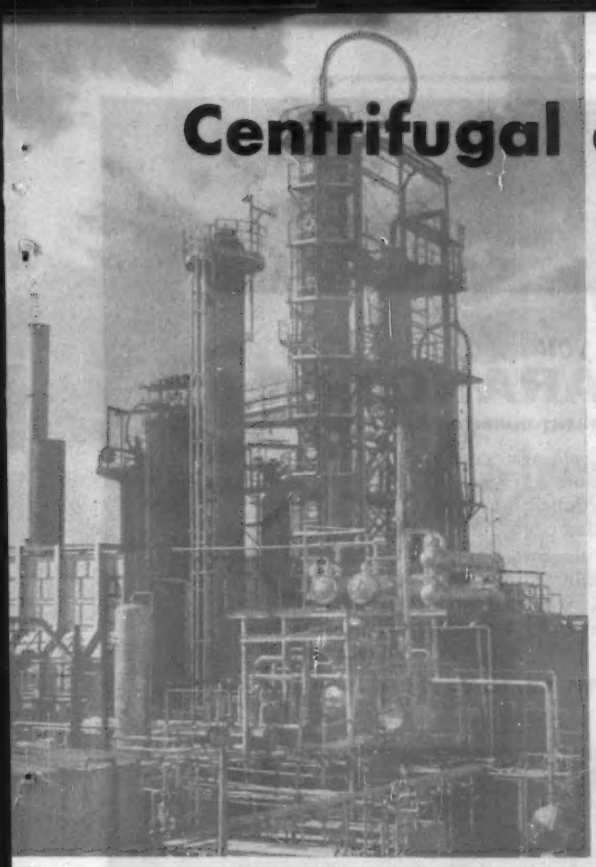

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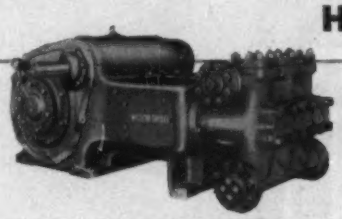
Here are Four Popular Types



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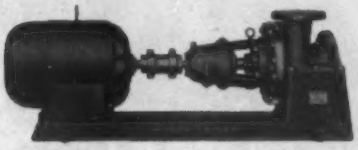

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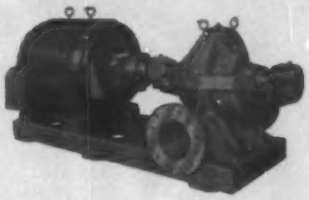

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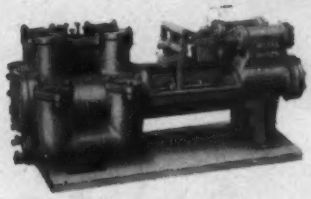

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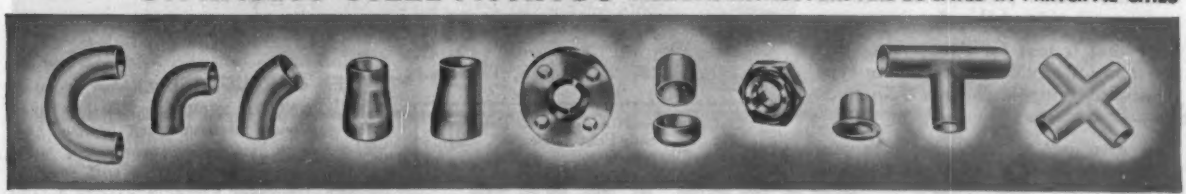

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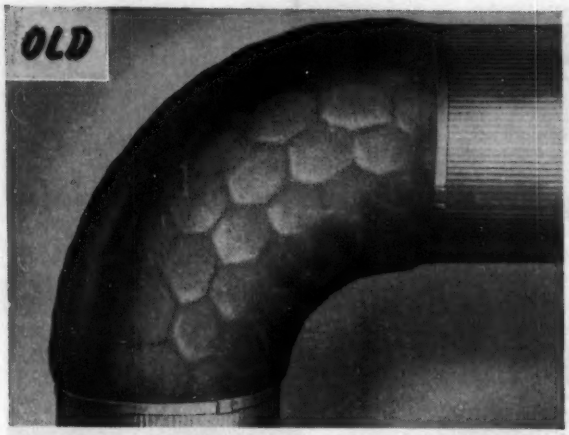

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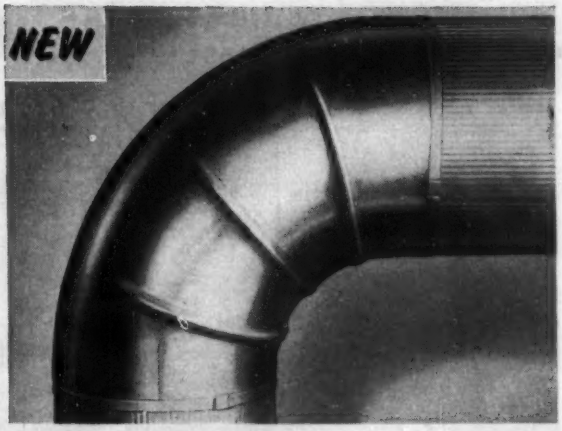

NEW CHILDERS ALUMINUM ELL-JACS now make possible neat, weather-tight aluminum protection from one end to the other of your insulated lines. Childers Ell-Jacs are precision formed for long-radius 90° and 45° ells and have factory-applied moisture barrier.

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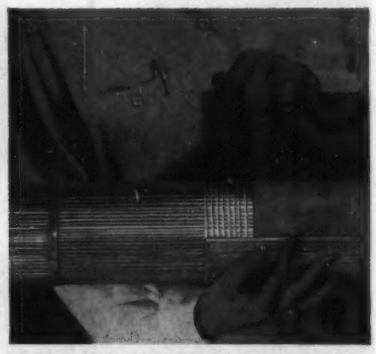
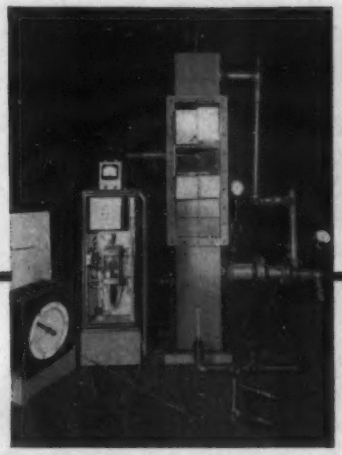
In Canada, write direct to Peerless Mfg. Co., Sub-Post Office 28, Calgary, Alberta.

For complete data see Refinery Catalog pp. 341-4, Chemical Engineering Catalog pp. 530a-d and Sweet's Industrial Construction File pp. 6b/Ch.



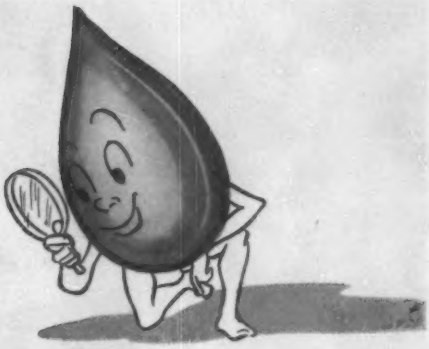
EXCLUSIVE LAP-SEAL, available at no extra cost, is a series of 8 ribs rolled into the underlapping edge of the jacketing, providing automatic measure of the 2" circumferential lap. Proper lap is assured without waste. Labor is saved. Where desired, a positive weather seal is easily made with Lap-Seal and a mastic.

DEEP CORRUGATED Childers Jacketing in 1¼" and 2½" corrugations is recommended for permanent protection and improved appearance of insulated towers, vessels, tanks. Deep Corrugated Jacketing with factory-attached moisture barrier is another product available only from Childers.

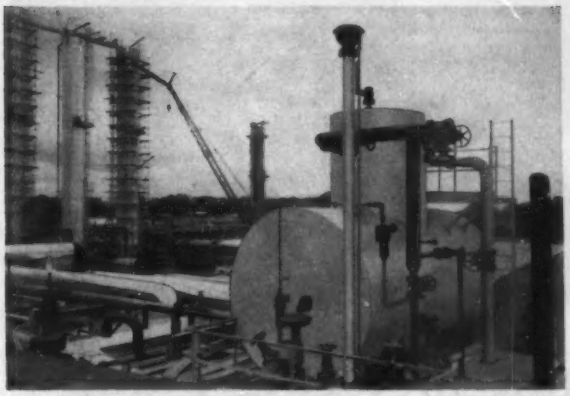


Pilot tray-type deaerator shown with continuous oxygen analyzer in test setup.

ALLIS-CHALMERS DEAERATORS



Looking for more effective deaeration?



Outdoor installation of Allis-Chalmers deaerator in southern chemical plant.

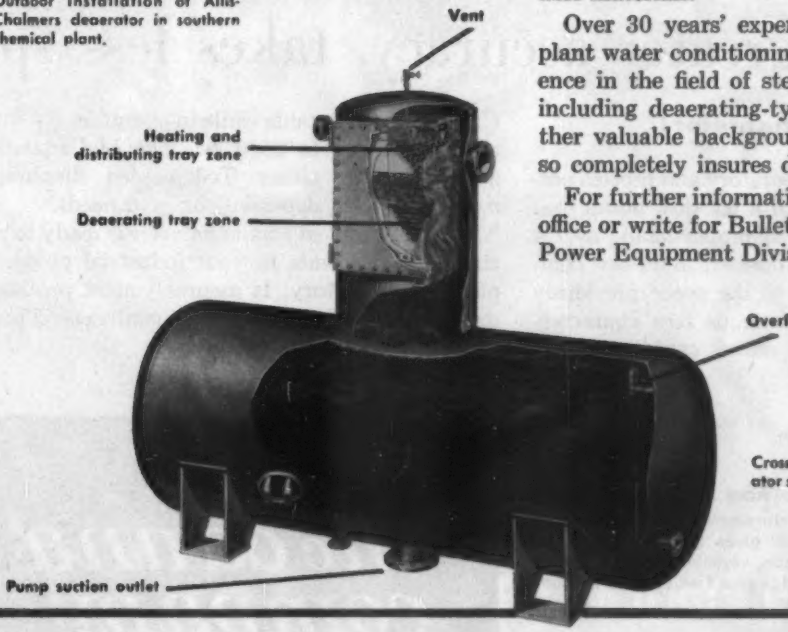
● If so — you'll be interested in the continuing research program at Allis-Chalmers to evaluate all factors in the design of deaerators.

This program includes the use of a specially built pilot deaerator with automatic oxygen analyzer and recorder. Operating factors and deaerating compartment design can be varied to study length of spilling edge of trays, heating area and method of flow. Results obtained with this setup are quickly translated into deaerators designed for optimum performance.

In addition to this continuous testing, metallurgical research is being done to select the most suitable materials.

Over 30 years' experience in the field of power plant water conditioning, and over 75 years' experience in the field of steam power plant equipment including deaerating-type condensers, provide further valuable background. No other manufacturer so completely insures deaerator performance.

For further information contact your nearby A-C office or write for Bulletin 28B8853, Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wis.

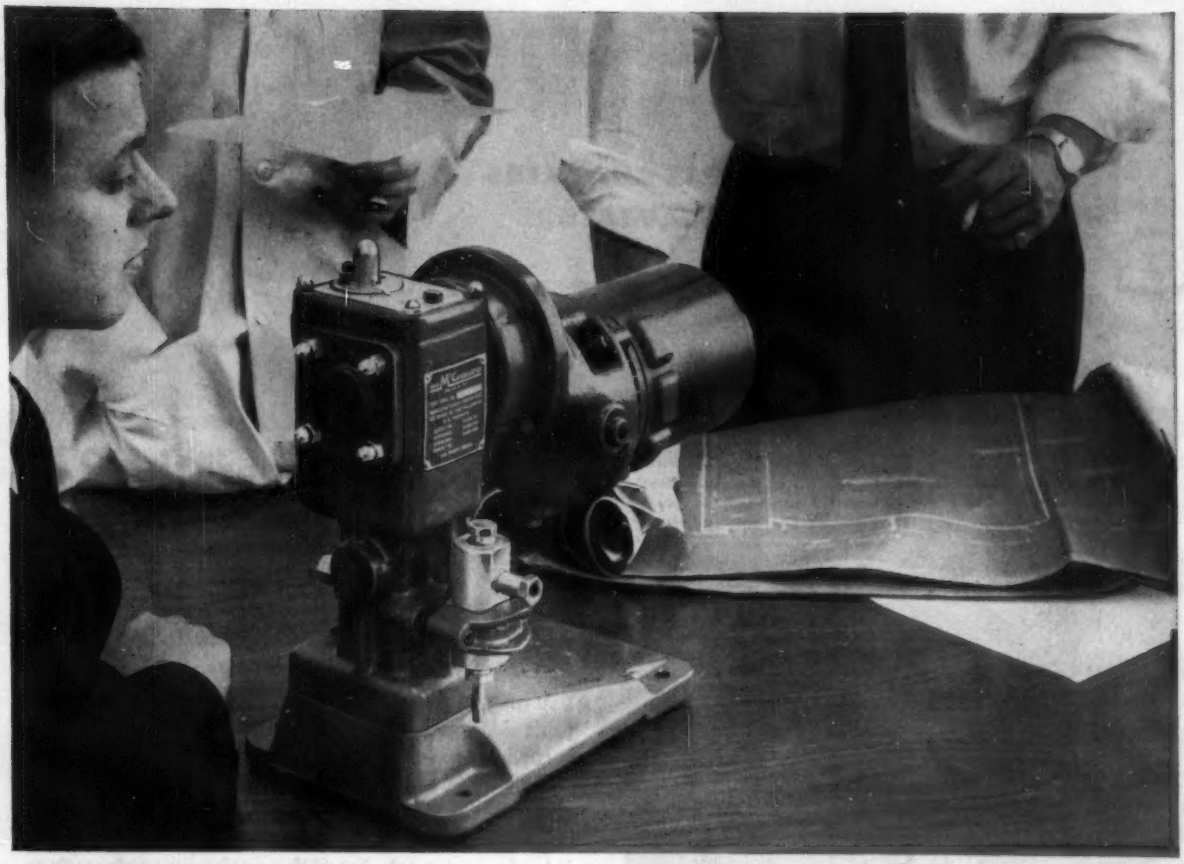


Cross section of tray-type deaerator shows water and steam flow.

ALLIS-CHALMERS

A-5674

For more data on advertised products, use Readers' Service Cards, last page.



You're looking at a new metering pump that offers greater accuracy, takes less space

Meet the new McCannameter!*

Here you see management, laboratory and process personnel getting acquainted with a packless pump that provides accurate metering and proportioning over a wide output range. Each is interested in its new compact design that takes only ⅓ the space previously required. Each likes the continuous flow characteristics available through the entire capacity range. Capacity is adjustable while in operation . . . pumping at pressures up to 2500 psi. The McCannameter is available with either Teflon-faced diaphragm or metallic bellows, depending on your needs.

The new, improved McCannameter is ready to provide these same benefits in your industrial process, pilot plant or laboratory. It assures you of precision and dependability. To really get acquainted, send today for full information. * PAT. APPLIED FOR

SEND FOR NEW BOOKLET
"McCannameter—The Meter That Pumps" gives the inside story of precision, versatility and reliability. Write for your free copy of Booklet No. 302.

HILLS-McCANNA COMPANY
4614 West Touhy Avenue, Chicago 30, Illinois
Specialists in Diaphragm Valves and Proportioning Pumps

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THE PEOPLE WHO KNOW AND CONTROL FLOW

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CAST ALLOY STEEL PIPENDS

EXTRA HEAVY BACK WALLS

100% MAGNAFLUX

18 X 14 REDUCING LATERAL FOR STEAM SERVICE 2005 LBS. AT 1000° F.

STANDARD BUTT WELDING FITTINGS TO ASA B-16.9

DOUBLE TEE FOR HYGROFORMING SERVICE

OHIO STEEL OFFERS

single responsibility

direct supervision

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THE OHIO STEEL FOUNDRY CO.

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ORB1

. . . here's why

CHECK THESE FACTS!

INTEGRITY OF MATERIALS

Farris metallurgy of parts offers as *standard*, stainless steel, rather than carbon steel in critical locations; and use of hardened parts for highest valve operating efficiency.

MINIMIZED SPARE PARTS INVENTORY

Since 1945 every new Farris part has been interchangeable with former parts, keeping inventories at minimum . . . with parts low priced!

NO OBSOLESCENCE OF DESIGN

Construction improvements — not repeated design changes — have resulted in user recognition, standardization of design; eliminating confusion and expense to the customer.

UNEQUALLED QUALITY AT COMPETITIVE PRICES

Freedom from changing inventory, new pattern problems and continuous new tooling permits lowest production costs, passed on to the user in lowest valve costs.

LICENSED TO OTHERS

In the Industry's interest, limited licensing arrangements were granted . . . A Farris patent number is your protection.

PROVEN SAFE PERFORMANCE

The complete dependability of Farris valves has been proven by 13 years of use in the field, under all service conditions.

Meets ASME-NB Requirements for ASME Unfired Pressure Vessel Code, Section 8 and ASME Power Boiler Code, Section 1.

Send for the NEW Farris Engineering Catalog. A complete, detailed listing of Farris Process Safety and Relief Valves, plus useful information to help you select the proper valve for your requirements.

Farris®

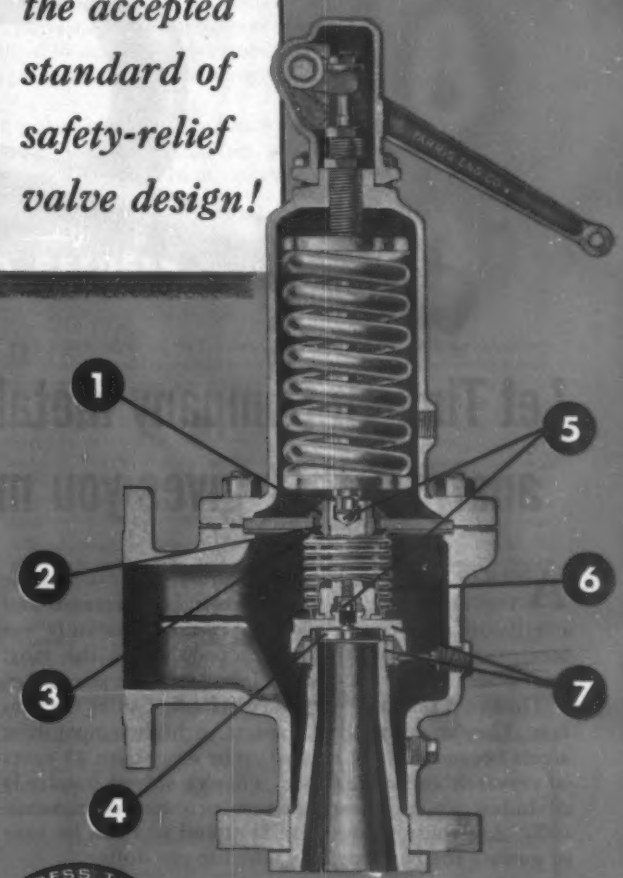
SAFETY-RELIEF VALVES

are your best buy

the accepted standard of safety-relief valve design!

Farris gave industry the ideal concept of a trouble-free, safe, safety-relief valve in 1945... and it has had little need for major design changes through the years. The proven excellence of design and construction has resulted in patent licensing to others, serving to reduce a confusion of designs which retarded the safety valve industry in prior years. Today, the Farris design—with or without its universally accepted optional "BalanSeal" bellows—represents the *standard* of the industry... it has been the standard for over 13 years.

With Farris valves in your process lines you'll know that another confusing design change isn't around the corner to plague you... you'll never worry about obsolescence of your spare parts inventory... you'll always benefit by integrity of materials in valve construction. You can be sure of all this because Farris full-performance valves have proven to be the *accredited leaders* in the field of safety.



1. 2½ to 1 ratio—guide length to guide diameter—prevents galling and hanging up.
2. High thermal expansion rate of sleeve guide and low thermal expansion rate of hardened stem retainer eliminates binding and galling even at elevated temperatures.
3. Sleeve guide provides solid baffle between body and bonnet, shielding spring from lading field.
4. Hardened stainless steel optically lapped flat disc—self aligning for maximum tightness.
5. Double universal ball joint from stem to disc for self alignment—eliminates effects of spring, temperature and piping distortion.
6. Stainless steel stress relieved "BALANSEAL"© bellows nullifies effect of back pressure and isolates internal working parts from lading fluid.
7. Cone-shaped disc holder directs flow away from guiding surfaces and forms fixed secondary orifice with single blowdown ring control for built-in capacity.

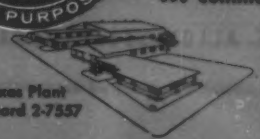
PROGRESS THROUGH HONEST PURPOSE

Farris ENGINEERING CORP.

536 Commercial Avenue, Palisades Park, N. J.

In Texas: 5405 Clinton Drive, Houston 20

Main Office
Palisades Park, N. J.
Windsor 4-6300

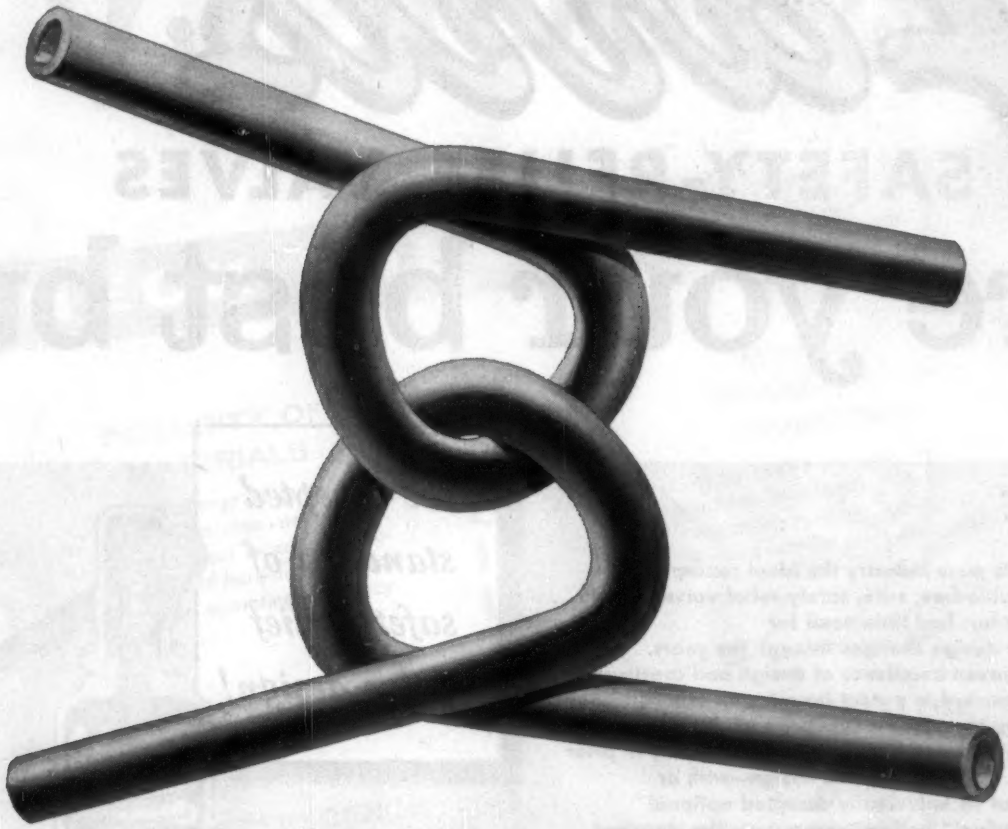


Texas Plant
Orchard 2-7557

affiliates:

FARRIS FLEXIBLE VALVE CORPORATION
FARRIS PICKERING GOVERNOR CO., INC.
FARRIS HYDROTORQUE CORPORATION
FARRIS HYDROSEAL CORPORATION

PUZZLED by pressure tube problems?



Let Timken Company metallurgists select the one steel analysis that gives you maximum tube life per dollar

A VARIETY of high temperature steels can handle the combination of pressure, temperature and corrosion that your operation creates. But only *one* steel analysis can handle your problem in the most economical way, give you maximum tube life per dollar.

Timken Company metallurgists can find it for you fast. They're recognized experts in high temperature steels because they're backed up by more than 25 years of research and experience. They've solved hundreds of industry's toughest pressure problems—economically. Ask these experts for help and you can be sure of getting the best possible tube life per dollar.

And we've got the steels to do the trick. You can get Timken® seamless pressure tubes in sizes up to 11″ O.D. x 3¼″ wall—available in all stainless and alloy grades to meet almost any combination of operating conditions. And because we make only electric furnace fine alloy steel, you can be sure of accurate analysis, uniformity from heat to heat, order to order, tube to tube.

Why not save money by letting Timken Company metallurgists solve your pressure problem? The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* STEEL

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Can You Call a Man a "Failure" at Thirty?

Men who think that success is only a matter of "a few years" are failures . . . however young they are!

How often have you heard some young man in business say, "I'll admit the job I have now isn't much but, after all, I'm only in my twenties."

Or: "Just about every executive in the company I work for is between 45 and 65. I have plenty of time to get ahead."

This *mistaken* idea that success comes automatically with time is easy to understand. Promotions do come regularly and effortlessly to young men of promise. *But* the day arrives, often abruptly, when that promise must be *fulfilled*. Native ability and intelligence can carry a man only to the mid-way point in business—beyond that he must *prove* his capacity to justify a position of executive responsibility. That calls for a practical, working knowledge of business fundamentals.

The time to build that knowledge—to lay a solid groundwork for your future progress—is now . . . *now* while time is still on your side. If you fail to recognize that fact, you'll know only struggling, skimping and regret when your earning power should be at its height.

FOR THE BUSINESS MAN WHO REFUSES TO STAGNATE

HALF the world is half asleep! Men who could be making twice their present salaries are coasting along, hoping for promotions but doing nothing to bring themselves forcefully to the attention of management. They're wasting the most fruitful years of their business lives... throwing away thousands of dollars they'll never be able to make up.

If you want to discover how to start to succeed while you're still young—if you want to avoid the heartbreak of failure in later years—send today for "Forging Ahead in Business"... one of the most practical and helpful booklets ever written on the problems of personal advancement. You will discover what the qualifications of an executive are in today's competitive market... what you must know to make $15,000, $20,000 or more a year... what you must *do* to accumulate this knowledge.

"Forging Ahead in Business" was written for ambitious men who seriously want to get down to bed-rock in their thinking about their business future; there's no charge for the booklet because, frankly, we've never been able to set a price on it that would reflect its true value. Some men have found a fortune in its pages. If you feel that it's meant for you, simply fill out and return this coupon. Your complimentary copy will be mailed to you promptly.

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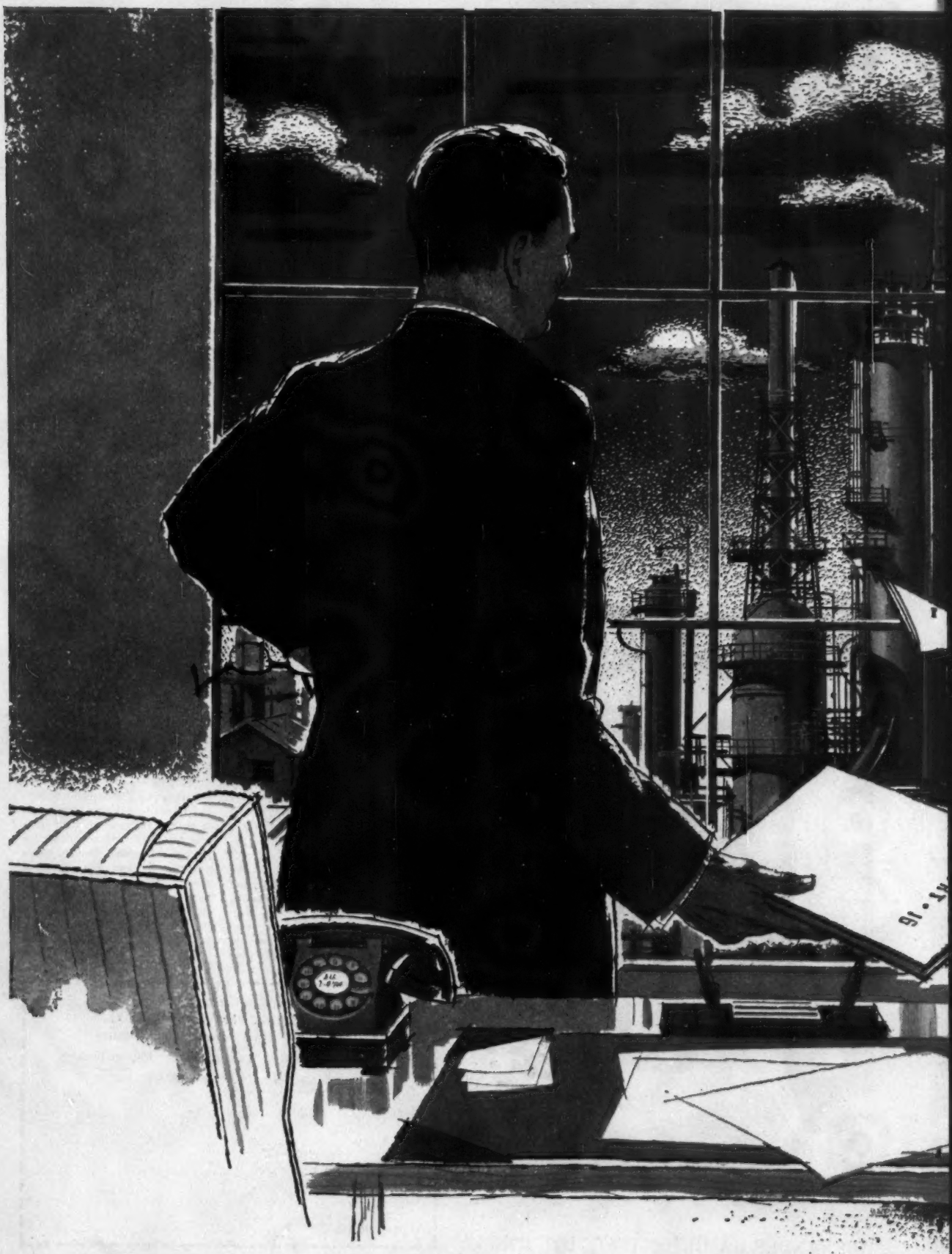

How our "knows" for your business can help you

Successful and profitable operations in the oil refining industry depend on accurate, complete, up-to-the-minute facts about all phases of management, manufacturing and marketing. UOP now offers refiners, potential or established, its comprehensive market research and economic evaluation service to provide all essential information from one qualified source. This service can provide a full and accurate analysis of all the factors affecting a successful operation. It covers such things as evaluation of markets and potentials, geographic factors and marketing trends, management and personnel analysis, product recommendations, process application planning, equipment analysis, financial requirements, earning potentials, facilities, manpower and raw material supply. Or whatever "knows" you need to know. UOP's more than 40 years of service to the refining industry is good insurance that you can depend on our providing the facts and guidance to help you to the most efficient and effective refining operation. This service is available to any refiner, anywhere, regardless of the size or scope of his operation.

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More Than Forty Years Of Leadership In Petroleum Refining Technology

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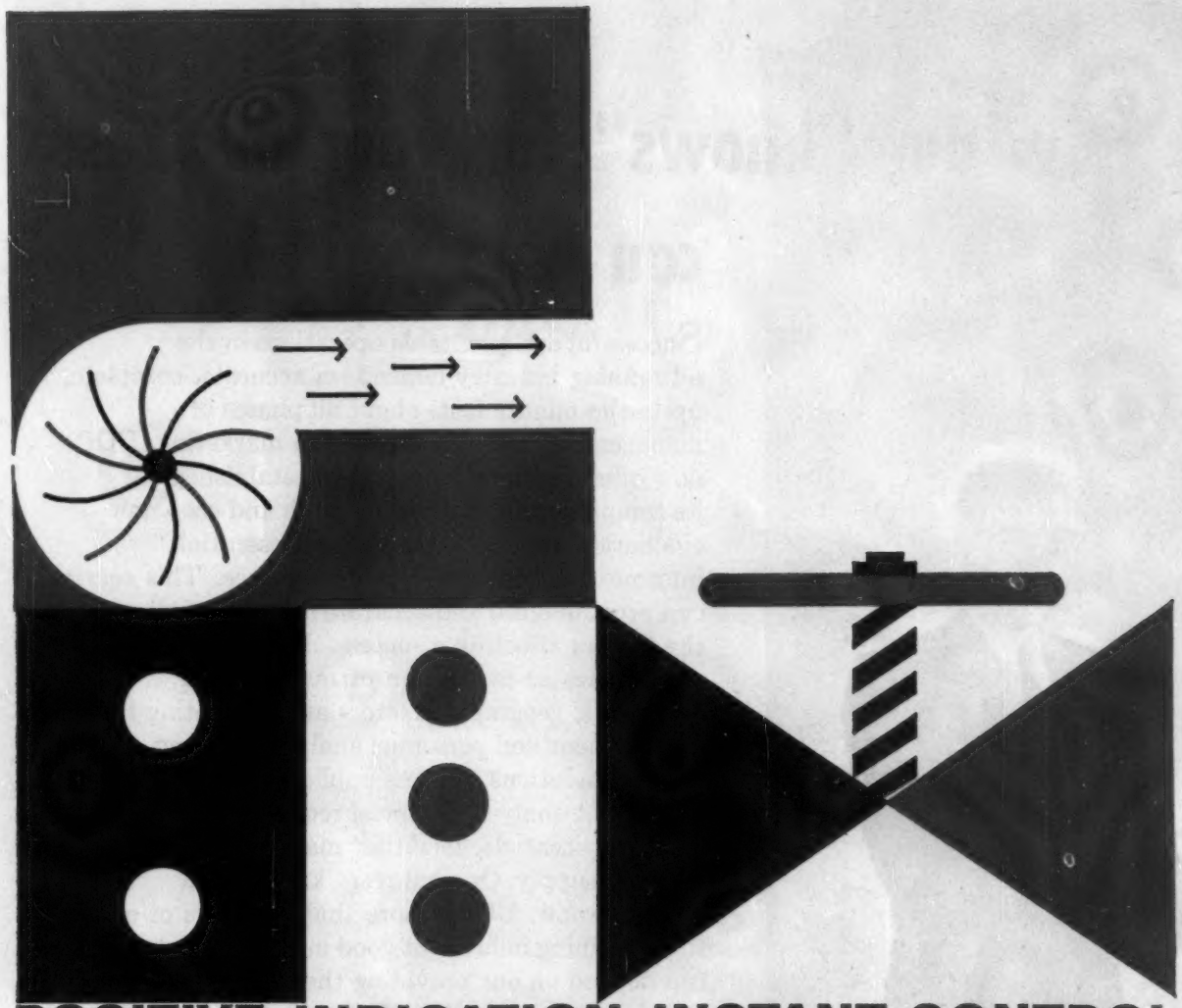

POSITIVE INDICATION-INSTANT CONTROL OF REMOTE PUMP MOTORS AND VALVES

S&J Gardtrol units continuously report actual conditions at remote points. They also allow instant change of conditions by the operator. Gardtrol Valve Monitor shows open, opening, closing, closed or stopped (partly closed) conditions. Gardtrol Pump Motor Monitor indicates on or off. Both have simple illuminated push button controls for all functions. Only one small wire—plus a common return—is needed between control unit and the field unit. S&J Gardtrol assures reliable supervisory control at lowest cost.

SHAND AND JURS GENERAL PRECISION EQUIPMENT CORPORATION GPE

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NEWEST OF THE GARLOCK **2,000**

SURFACE
Treated with elastomeric binder and powdered graphite . . . serves as a surface leveling and friction reducing element.

JACKET
90% asbestos yarn reinforced with 2 strands of inconel wire for corrosion resistance as well as maximum heat resistance.

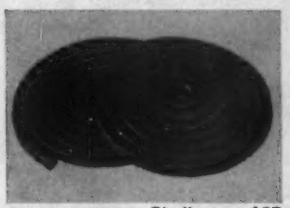
CORE
Long fiber asbestos, graphite, and a corrosion inhibitor all bonded together in a way which assures flexibility.

NEW valve stem packing . . . STYLE 127 for high pressure, high temperature Service

Here's an outstanding valve stem packing which is ideally suited to extreme steam conditions. Withstands pressures of 4000 psi., and steam temperatures to 1200°F. as long as stuffing box itself does not exceed 750°F. It is unsurpassed as a high temperature oil refinery or steam power plant packing.

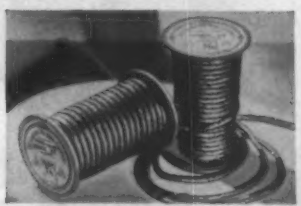
This Style 127 Valve Stem Packing is the newest member of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals to meet all your needs. It's the only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him . . . ask about the new Style 127.

OTHER GARLOCK VALVE STEM PACKINGS



Style 5855—Similar to 127, but for lighter duty. Costs less, too.

Style 17—A braided asbestos yarn treated to resist steam at high pressures and temperatures to 600°F.



Style 117—A braided (or twisted) asbestos yarn treated for service against steam at low to medium temperatures.

THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

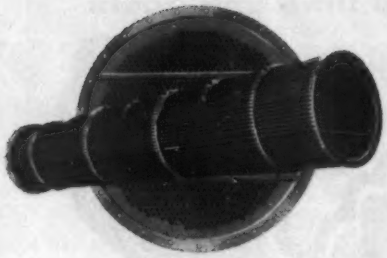
GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

RETUBE YOUR BUNDLES WITH

PHELPS DODGE HEAT EXCHANGER AND CONDENSER TUBES

FOR LONG-RUN RELIABILITY!



- Wide range of finest quality copper-base alloys—bi-metal combinations—to fit your application needs.
- Well-stocked, nation-wide warehouses at Houston, Tulsa, Los Angeles and Bayway, N. J.
- Experienced engineering staff at your service to help solve tube corrosion problems.

Specify Phelps Dodge . . . a leading manufacturer of tubes for the fabricators of heat exchangers and condensers!

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!

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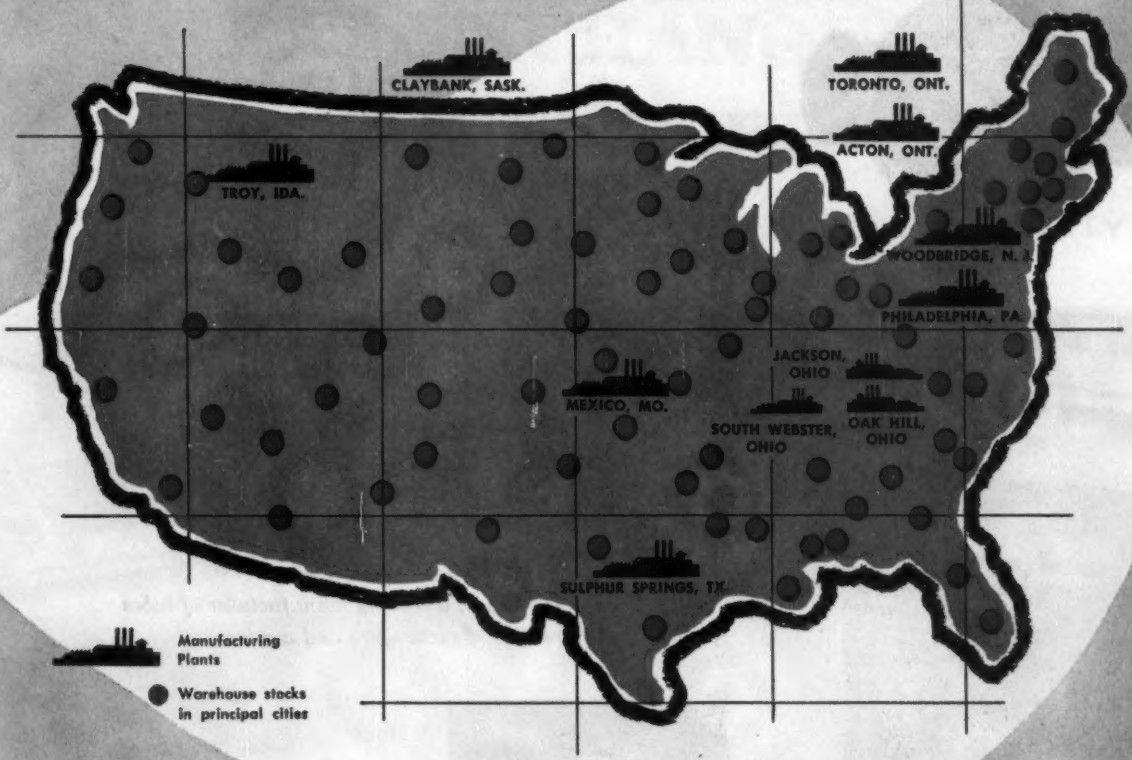
REFRACTORY PRODUCTS

manufacturing and warehouse facilities strategically located to save you time and costs



11 A. P. Green manufacturing plants and warehouse stocks conveniently located throughout the United States and Canada, Save You Money 7 Ways.

- **Lower Shipping Costs . . . from nearby manufacturing or warehouse point.**
- **Lower Capital Investment . . . your capital is not tied up in warehouse space.**
- **Lower Inventory Costs . . . you need inventory only for *immediate* needs.**
- **Lower Inventory Losses . . . buy on current prices . . . less breakage while in storage.**
- **Increase Production Space . . . free storage space for profitable production.**
- **Lower Labor Costs . . . deliveries to point of usage . . . no inplant moving of stocks.**
- **Maintain Steady Production . . . reduce down time waiting for materials.**

Your A. P. Green Distributor is Listed In The Yellow Pages of Your Telephone Directory, or write:

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

PLANTS:
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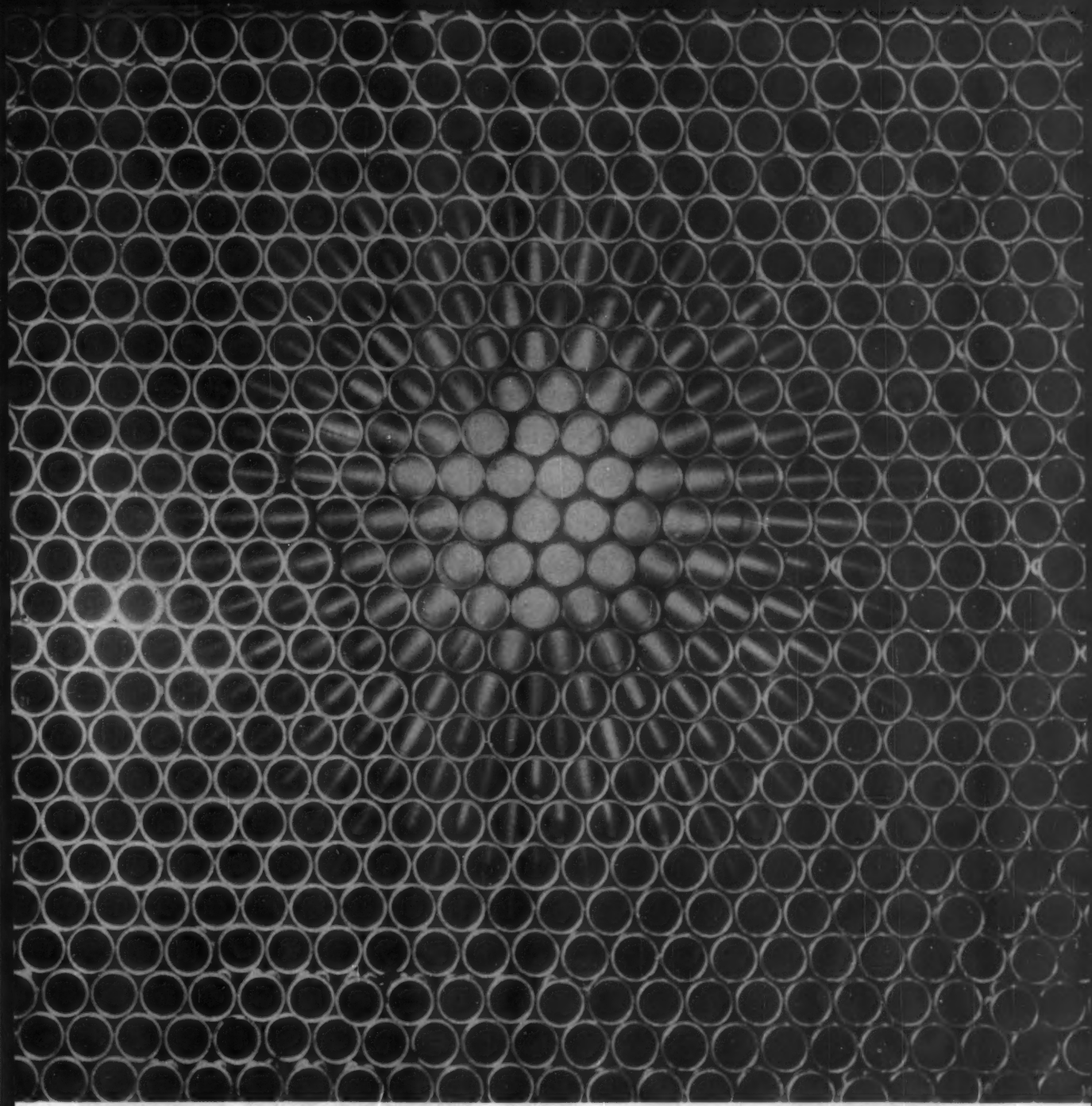
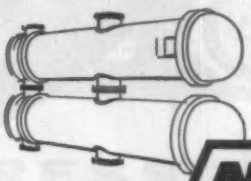
IN CANADA:
A. P. Green Fire Brick Company, Ltd., Toronto 15, Ontario

Distributors In The Principal Cities of The World



READY TO BUNDLE into heat exchangers for chemical and petroleum service, tubes and other standard components are kept fully stocked for assembly-line production at Kellogg's fabricating shops in Jersey City. Whatever your requirements, Kellogg assures strict conformance to the highest engineering and fabricating standards. For prompt deliveries plus engineering excellence at optimum cost, call Kellogg's Fabricated Products Division.



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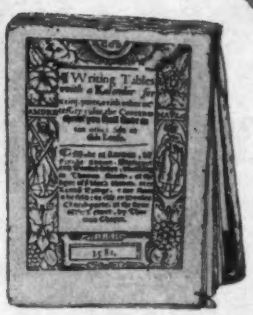
M W KELLOGG

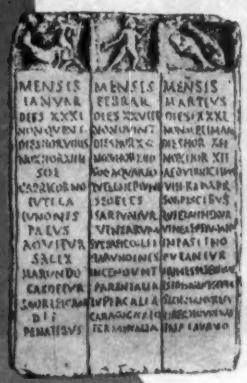
Scandinavian Calendar—Between 8th and 14th Centuries



English Tables—16th Century

Operating time of Clark Centrifugals

Roman Farmer's Almanac—1st Century A. D.



Saxon Calendar—About 6th Century

Aztec Calendar Wheel—Before 1479

totals 19 CENTURIES

Operating experience recorded by Clark centrifugal compressors totals 1,981 years. Providing rugged, reliable service 'round the clock, they have compiled this lengthy performance record within the actual time of only 10 years.

When Clark began to build centrifugal compressors a decade ago, pressures of 100 psi. were not considered practical. Today, as a result of Clark advanced engineering and design, Clark centrifugals are operating at over 5,000 psi. From the first, they have proved themselves in the field.

Clark builds two basic types of centrifugals. The horizontally split case type is designed for low to moderately high pressure ranges. The vertically split case type is used for extremely high pressure conditions. With capacities ranging from 1,000 to more than 150,000 CFM., Clark centrifugals are being used in new and ever widening applications throughout the world.

For all the facts about these performance-proved compressors backed by Clark's *encyclopedia of experience*, call your nearby Clark engineer. Or write today for Bulletin 150 to Clark Bros. Co., 1303 Lincoln Avenue, Olean, New York.

CLARK BROS. CO.

One of the Dresser Industries

Sales and service outlets in principal cities throughout the world

CLARK® — ONE OF THE DRESSER INDUSTRIES

CENTRIFUGAL COMPRESSORS

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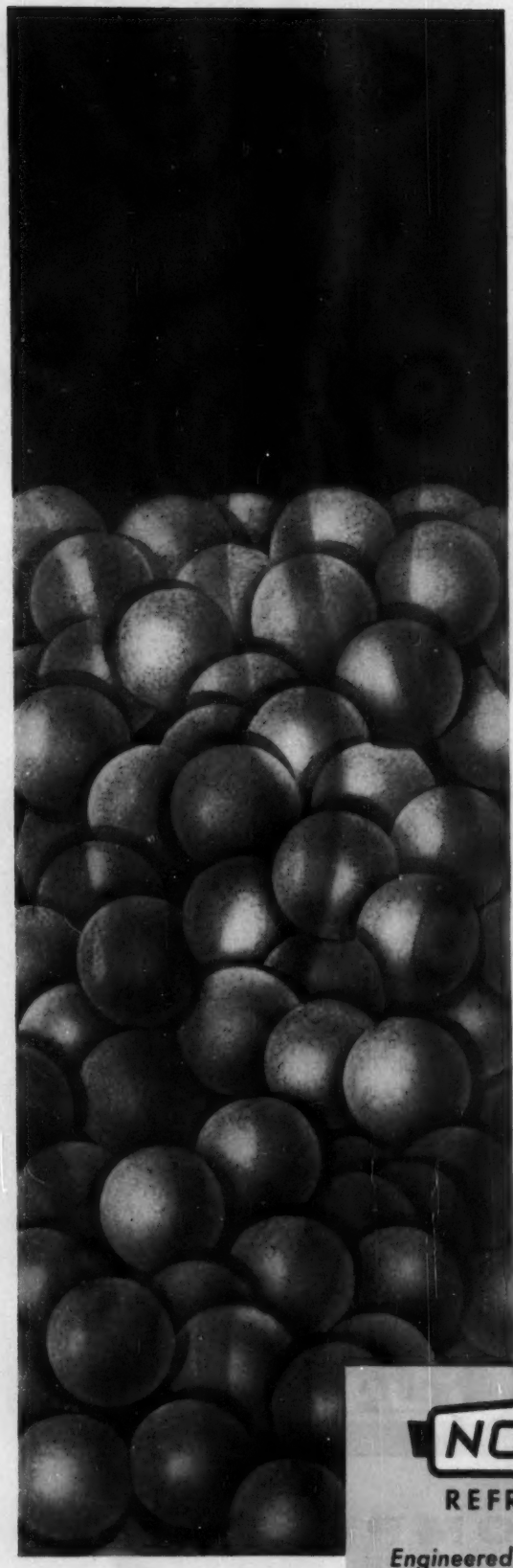


ALUNDUM*
Low Surface Area Catalyst Carriers
...add speed and efficiency to many processing reactions

Crystalline in nature, Norton ALUNDUM catalyst carriers have excellent mechanical, thermal and chemical stability. The most widely used type has low surface areas of less than $1 m^2$/gram, combined with high alumina content of 77% to 92%.

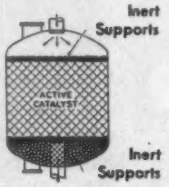
Shapes and Sizes: low surface area type; spheres 3/16" to 1½" diameter; pellets ⅛" x ⅛" to ½" x ½"; rings ⅛" x ⅜" x ⅜" O.D. to 1" x 1½" x 1½" O.D.

Other Physical Properties: apparent porosity 10-50%; water absorption 3-25%; bulk density 1.90-3.15 gr/cc; volume bulk density 65-80 lbs/ft^3; crystal structure alpha alumina and mullite.

Typical Applications: processing phthalic anhydride, maleic anhydride and ethylene oxide; also in protective atmospheres and synthetic gas generation.

Suspending active catalysts effectively

In fixed bed convertors, Norton inert supports are located to suspend active catalysts at given levels, as shown in diagram. Made of dense, rugged, electrically fused materials they have great resistance to breakdown and no chemically reactive effect on the processing.



Other carriers and supports

are produced by Norton with intermediate surface areas. On request, any type may be prepared from other materials, such as CRYSTOLON* silicon carbide, MAGNORITE* fused magnesia, zirconium oxide, silica, etc. For further facts call in your Norton Refractories Engineer, or write to NORTON COMPANY, Refractories Division 462 New Bond Street, Worcester 6, Massachusetts.

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These valves are available in either non-rising stem, or outside screw and yoke patterns.

Walworth iron body saddle type wedge gate valves are suitable for use on steam, water, gas, gasoline, oil, and many process lines. They are easy to take apart, simple to service, fast to reassemble. Walworth saddle-type valves are available in a wide range of sizes in eleven different combinations of design and materials including bronze-mounted, all-iron, and ni-resist; with both flanged and screwed ends. All types can be repacked under pressure when fully opened or fully closed.

Ask your local Walworth distributor to give you complete information or, write for circular.

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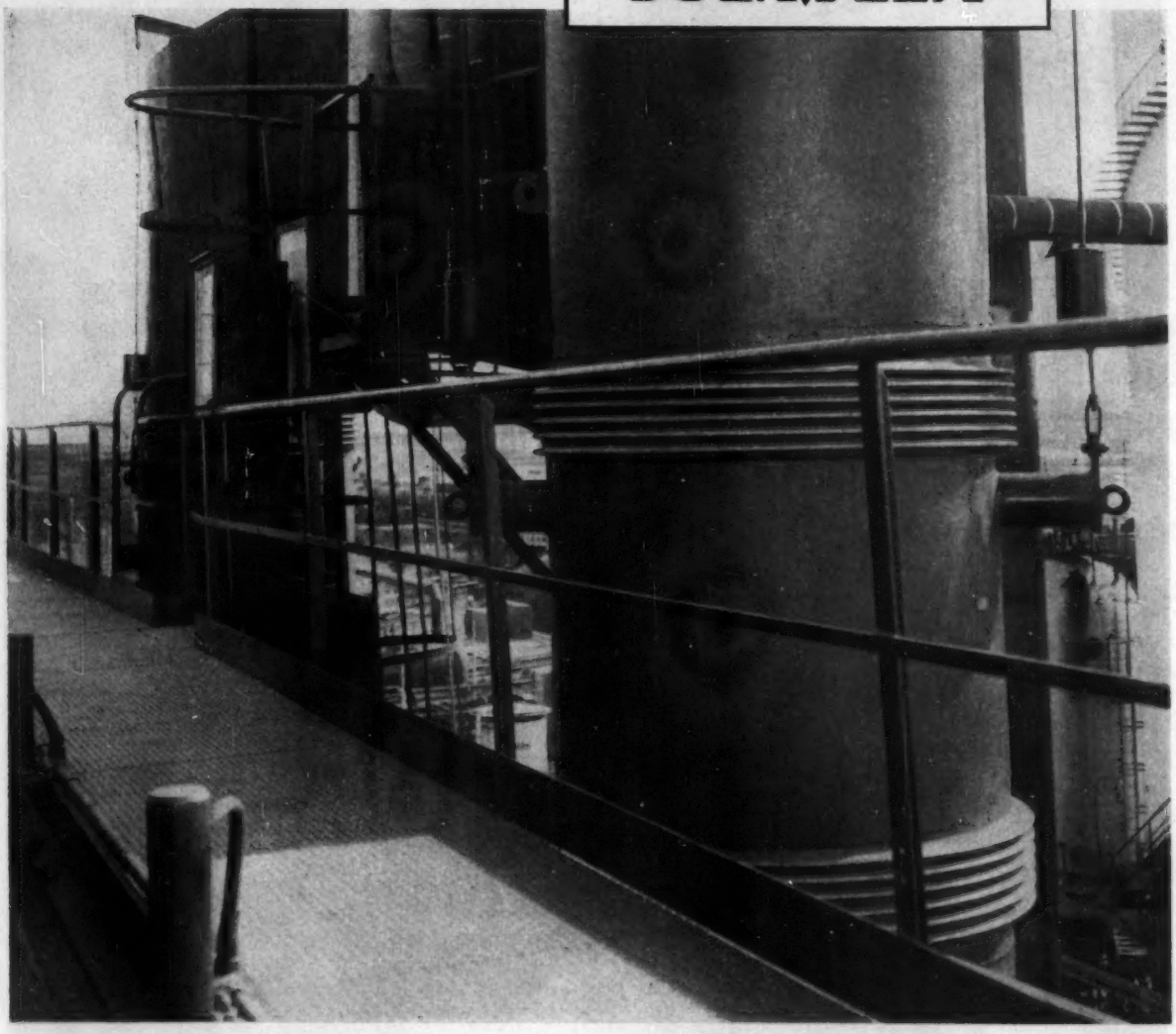
Leading firms use **SOLA-FLEX®**



Giant Sola-Flex joints used by Standard Oil Company in El Segundo plant

THESE RUGGED 54-inch Sola-Flex expansion joints are in service at Standard Oil Company of California's El Segundo refinery. They are an important example of why more and more of America's leading businesses – petro-chemical, power, nuclear and others – rely on Sola-Flex joints to help solve difficult temperature and pressure problems.

Solar manufactures the most comprehensive line of bellows and expansion joints in the world. They are made from a wide variety of stainless and high alloys for important nuclear, missile and industrial applications – in sizes ranging from ½ in. to 35 ft in diameter. They are built for service from –320 F to 1200 F. And they tame "hard-to-handle" pressures up to 3500 psi for special applications.

A new pamphlet describes Solar's complete line of Sola-Flex bellows and expansion joints. Write for it to Dept. D-161, Solar Aircraft Company, San Diego 12, California.

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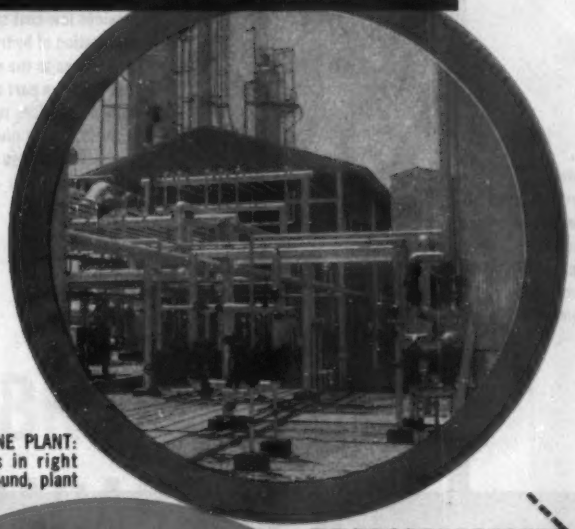
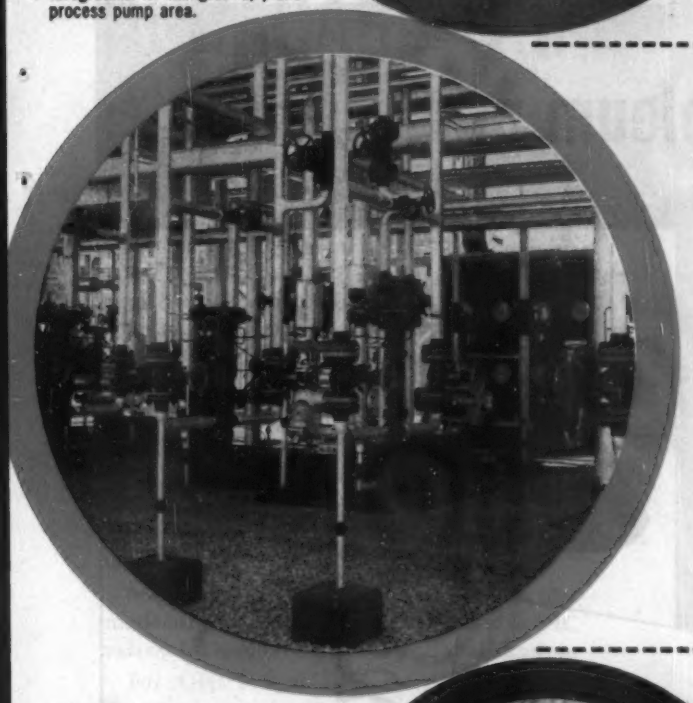
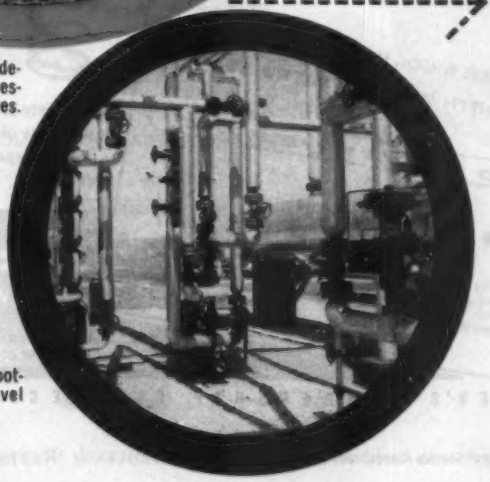
when you specify orbit forged steel asa class valves for your processing area



AT A KANSAS GASOLINE PLANT: Propane dehydrators in right foreground. In background, plant process pump area.



In foreground, depropanizer and debutanizer, reflux accumulator pressure relief and level control valves. Reflux pumps in background.



Left to right, de-ethanizer feed, bottoms exchanger, and liquid level control valve.

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3. vapor-proof forged steel body and bonnet
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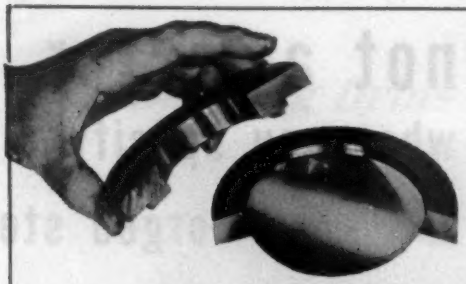

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discs of precious metals, resistant to most corrosive agents and unattacked under conditions that base metals could not withstand. Specific physical properties ensure bursting only at the predetermined pressure.

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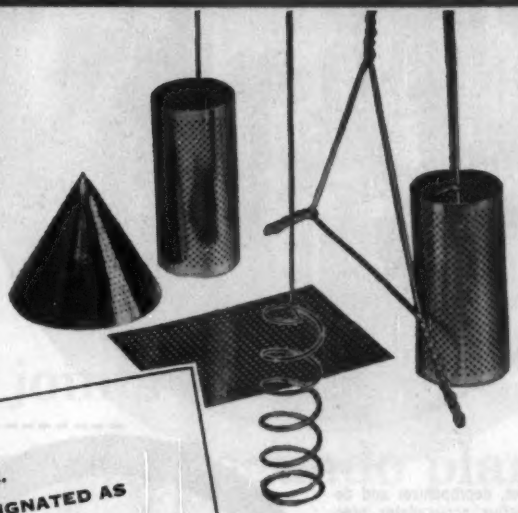

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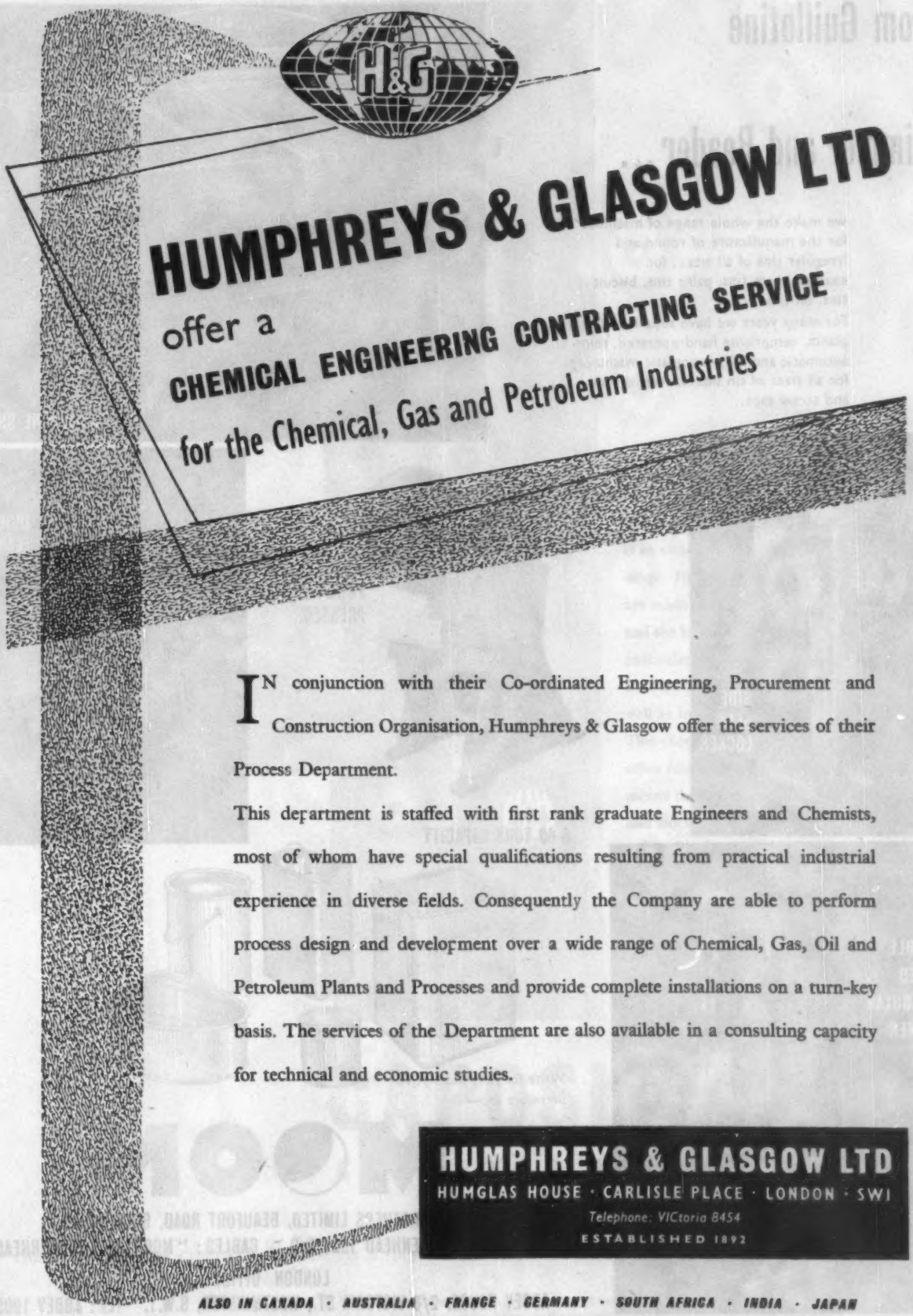

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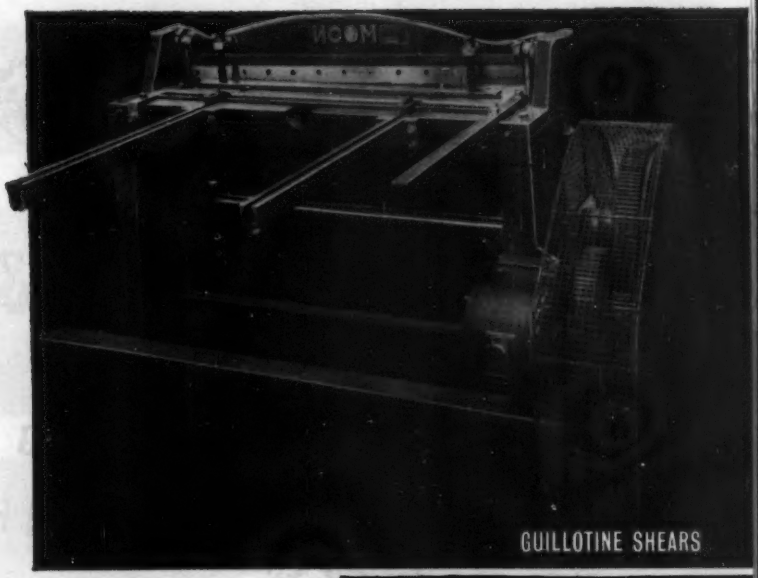
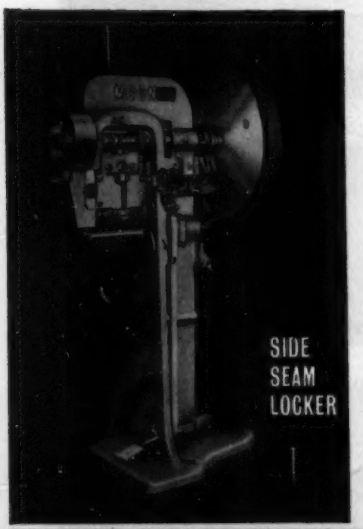
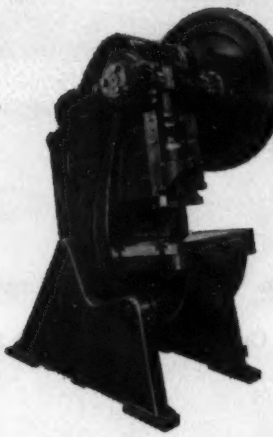
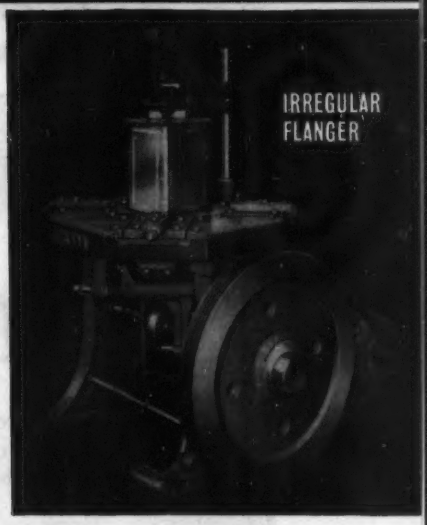
we make the whole range of machines for the manufacture of round and irregular tins of all sizes; for example, ham tins, paint tins, biscuit tins, oil tins, etc.

For many years we have supplied complete plants, comprising hand operated, semi-automatic and fully-automatic machinery for all sizes of tin boxes, steel drums and screw caps.









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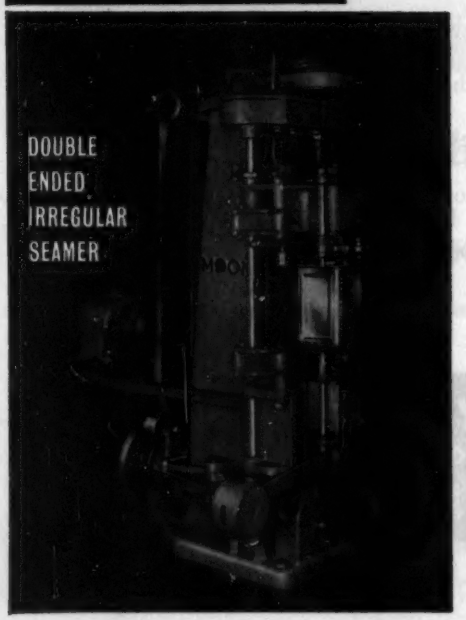

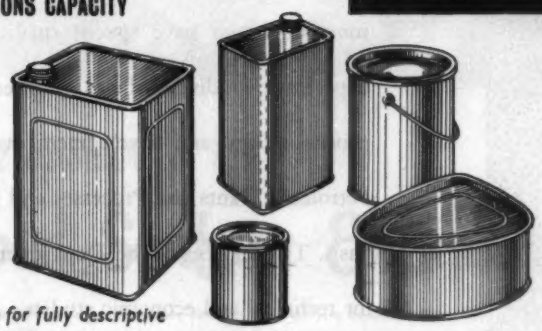

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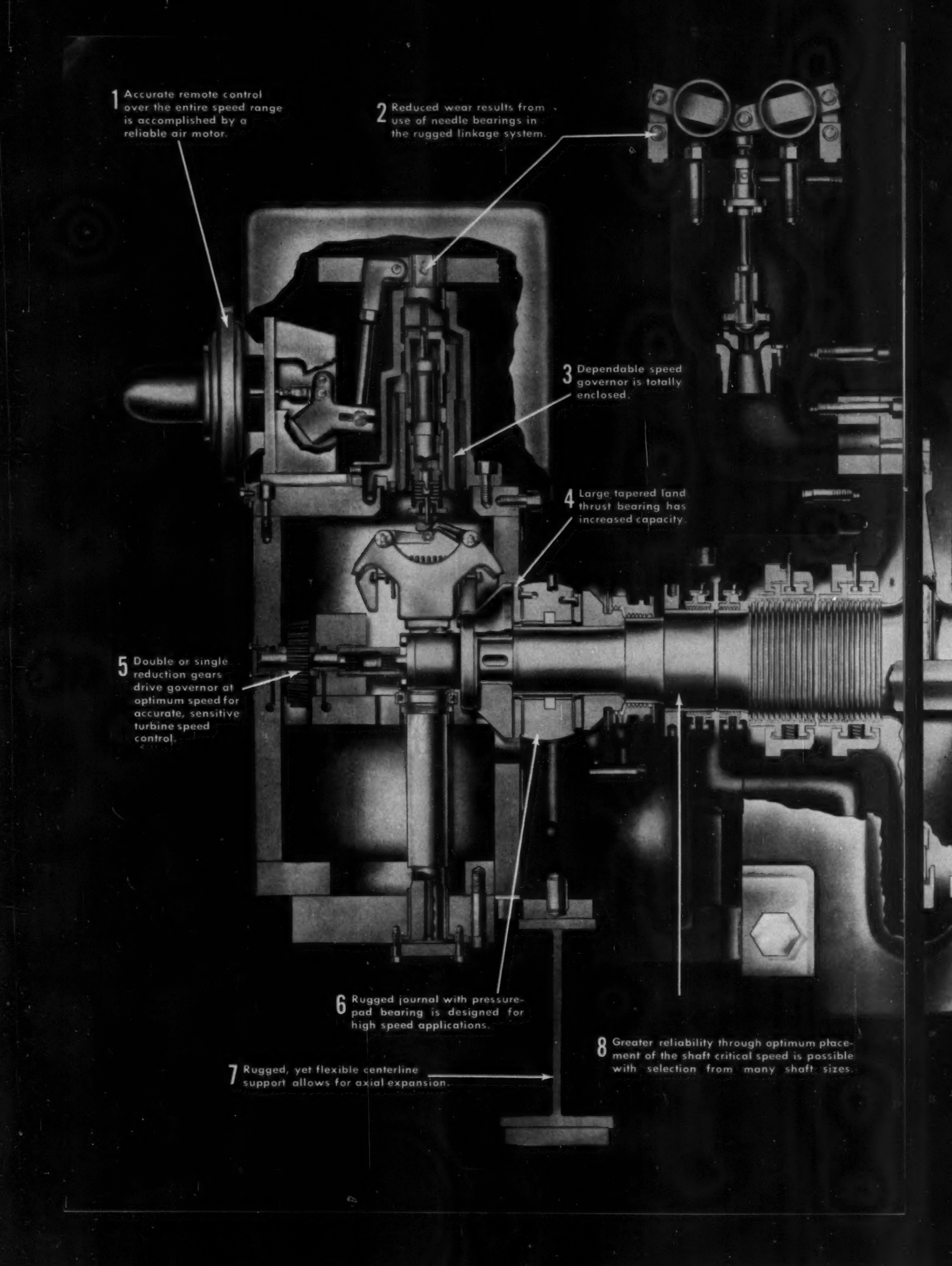
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by matching process demands for more hp, higher rpm

Now you can drive larger and faster compressors with rugged General Electric mechanical drive turbines. G-E turbine design matches the trend to higher horsepower and speed with a new front standard which allows power in the range of 15,000 hp and speeds up to 12,500 rpm. It can help bring profitable power to your operations.

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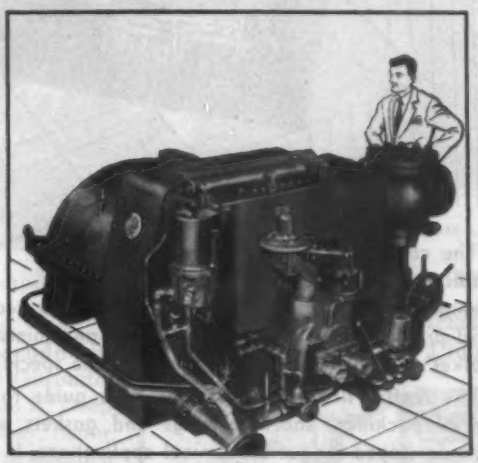
Find out more about the long term economy of dependable G-E mechanical drive turbines. Contact your nearby G-E Apparatus Sales Office, or write to Section 241-10, General Electric Company, Schenectady 5, New York.



G.E.'S HIGH-SPEED mechanical drive turbine line meets modern process industry demands for higher horsepower and higher speed.

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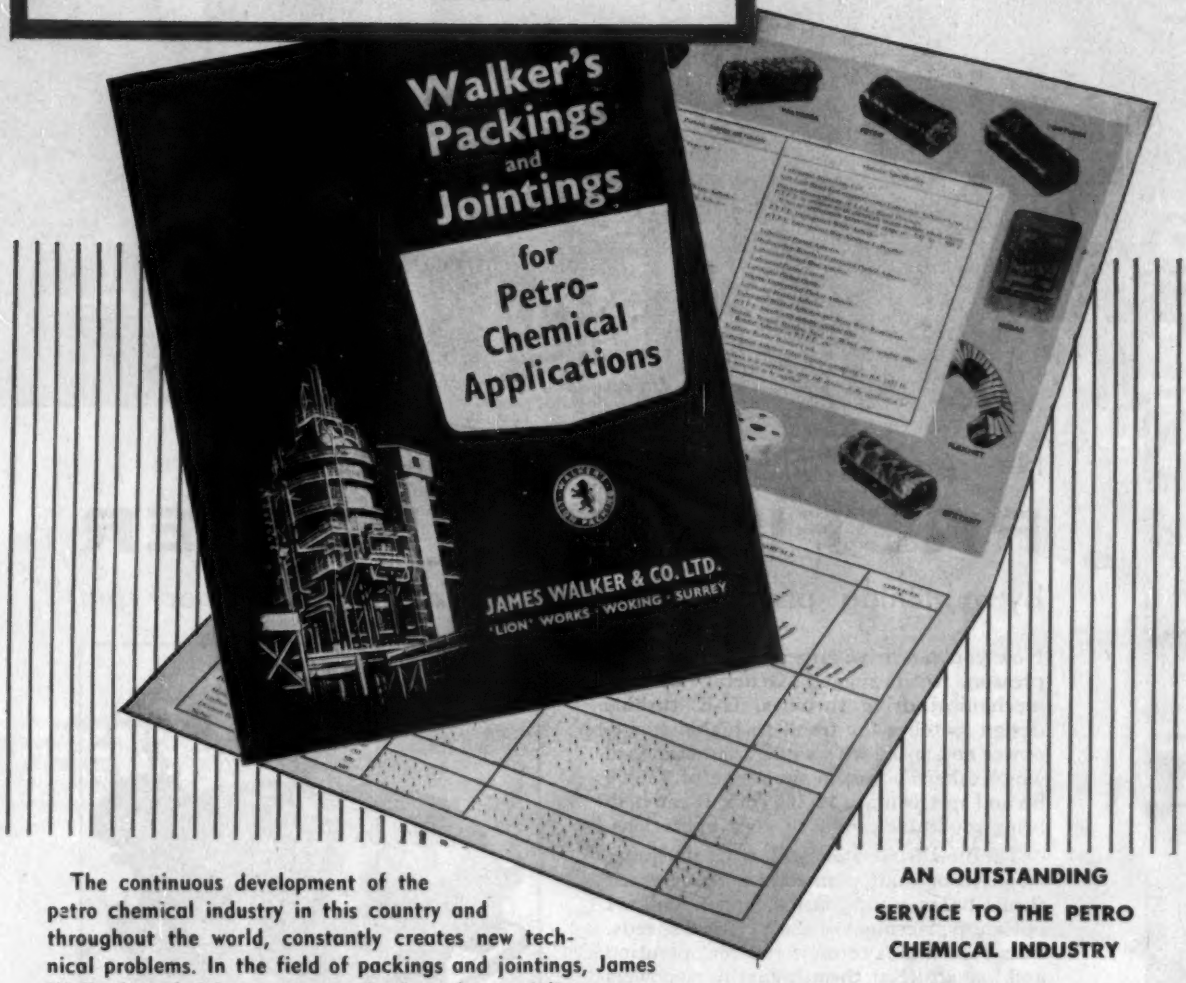

The continuous development of the petro chemical industry in this country and throughout the world, constantly creates new technical problems. In the field of packings and jointings, James Walker's technicians are recognized as *the* specialists.

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High pressure water jet shatters solid Gilsonite. Flume hose washes particles down mine floor to pipeline.

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Progress in the West means...

New sources of gasoline to fuel 5½ million more motor vehicles by 1965†

†*In 11 Western States*

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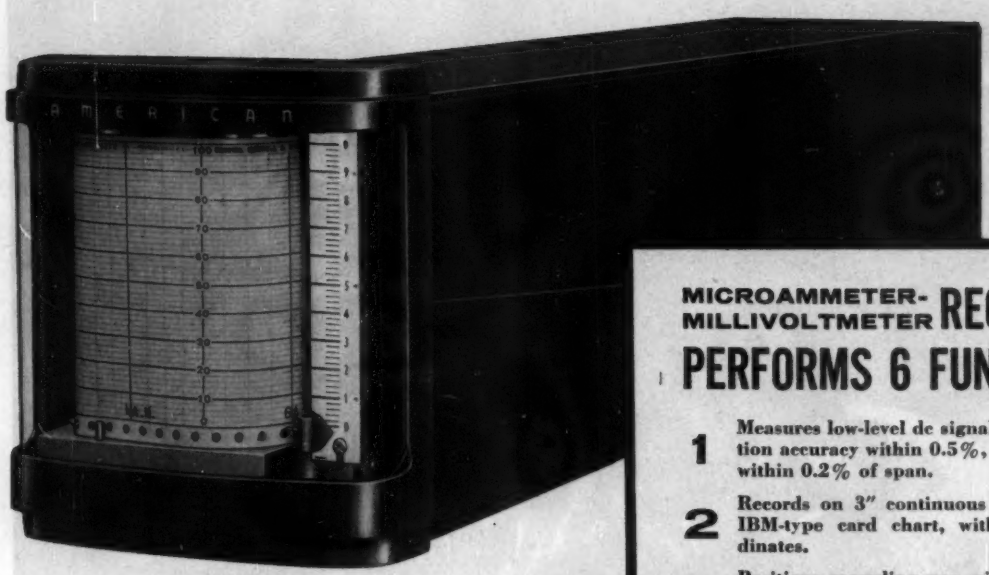

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This highly sensitive 'American-Microsen' Series 130 Recorder, with all its operational advantages, costs less than others designed for the same jobs. Simple design, precision components and rugged construction assure sustained high accuracy and freedom from maintenance. The recorder withstands shock up to 30 times gravity.

Since its introduction less than a year ago, the Series 130 Recorder has been very successful because it offers a more accurate and durable method of recording dc electrical signals at lower cost. It is being used to record outputs of many different electrical transducers – for measurement of such variables as pH, gas analysis, signal strength and others.

Many laboratories have adapted the Series 130 Recorder to their analytical and scientific instruments to assure accurate, permanent records of results which previously were only indicated. The Recorder can be used with any device which can provide 200 microamperes or more in its output circuit.

Standard 'American-Microsen' Series 130 Recorders are priced at $250.00. All models have ample power to operate alarm contacts which can be supplied at extra cost. *Write for Bulletin MG10.*

SPECIFICATION BRIEFS

POWER SUPPLY: 115 volts, 60 cycles. **POWER REQUIREMENT:** 9 watts.
INPUT RANGES: Voltage – 0-20 millivolts to 0-100 volts dc. **Current** – 0-200 microamperes to 0-100 milliamperes dc. **Input Sensitivity** – 6700 ohms per volts.
ACCURACY: ± 0.5% of span. **SENSITIVITY:** ± 0.2% of span.
REPEATABILITY: ± 0.25% of span.
EFFECT OF SUPPLY VOLTAGE: Less than 0.5% error 90-130 volts.
EFFECT OF AMBIENT TEMPERATURE: Less than 0.5% error 50° to 100° F., and less than 1% to 130° F.

RESPONSE TIME: Fast Speed – 0.2 seconds standard for 63% of fullscale input change; up to 0.05 seconds for 63% on special order. **Slow Speed**– approximately 4 times fast speed setting.
CHART SPEEDS: Strip Chart – 1" per hr., standard; 3" or 6" per hr. available. **Card Chart** – 1 rotation per day, standard.
SPAN ADJUSTMENT: ± 10% of span. **ZERO ADJUSTMENT:** ± 100% of span.
PANEL SPACE REQUIRED: Only 27 square inches.

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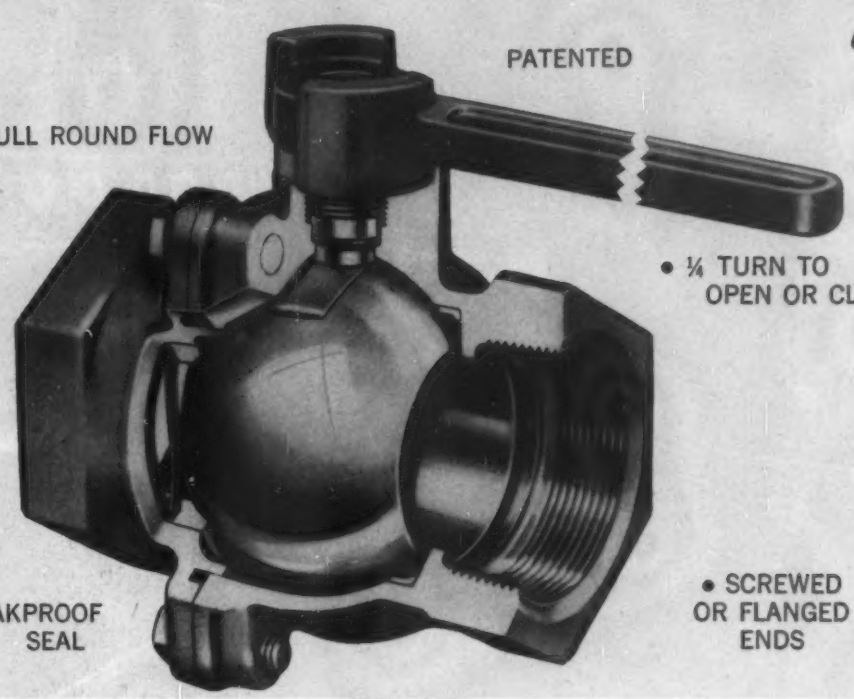
MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL



Who sends Valentines to a Rockwood Ball Valve?

Rockwood Ball Valves are operating, without leakage, in plants throughout the country, and the pleased comments we receive read like valentines:

A brewing company has opened and shut their Rockwood Ball Valves over two million times — and their valves are still going strong!

An oil company was surprised (although we don't know why — it's a common occurrence) when Rockwood Ball Valves stopped leakage other valves could not stop.

A company boiling starch found Rockwood Ball Valves lasted longer than any other valve previously used.

A tannery tells us Rockwood Ball Valves are the quickest, easiest valves to open and close.

Frankly, we can't blush — it would be false modesty. Rockwood Ball Valves are perfect for many jobs — we build them that way. They come in all pipe sizes, rated at 300 W.O.G. Tell us where to send it — and we'll give you a booklet with complete information. Valves are tested and listed by Underwriters' Laboratories, Inc. Distributors in principal industrial areas.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
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Please send me your illustrated Rockwood Full, Round Flow Ball Valve folder.

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Engineers from Blaw-Knox and Arthur D. Little, Inc., make intermediate check on data as operator (on left) watches signals on control console of electronic computor

Power Piping Division develops

new "6 x 6" Flexibility Matrix Method —cuts calculation time from months to a day

Present day operating requirements demand power piping systems that can handle extremely high temperatures and pressures—often up to 4500 psi and 1100° F. Under these critical conditions pipe may expand as much as ten inches in a hundred feet of pipe.

To be sure of adequate flexibility of the piping system, the terrific stresses set up by this expansion must be accurately computed before fabrication. And these computations are often so complex that skilled stress analysts have had to take two to three months, sometimes more, to complete them.

Now, by using the Blaw-Knox "6 x 6" Flexibility Matrix Method, computation time is cut to one day.

Developed in an 18-month joint research project of the Blaw-Knox Power Piping Division and the Arthur D. Little, Incorporated, Cambridge, Mass., research consultants, this new method of computation takes advantage of the high speed and accuracy of electronic computers.

Results are: Completely automatic computation with no limitations on the complexity of the systems. Full accuracy—as any inconsistencies in the input data are detected by the machine and all results are carried to six significant figures. Tremendous saving in time. Highly profitable saving in costs.

Originally developed for calculating stress analysis on systems fabricated or designed by Blaw-Knox Power Piping Division, this new method of computation is now available to consulting engineers, companies and individuals responsible for the design of power piping systems.

Bring your piping stress problems to our Power Piping Division for a discussion with our experienced piping engineers.

BLAW-KNOX COMPANY
Power Piping and Sprinkler Division
Pittsburgh 33, Pennsylvania

Complete facilities for prefabrication and erection of piping systems—complete line of functional spring hangers, assemblies and vibration eliminators—complete engineering and installation of Automatic Sprinkler Systems

For more data on advertised products, use Readers' Service Cards, last page.

SPECIAL REPORT ON

PETRECO

Electric Lube Oil Treating

Low installation costs range from $60 to $100 per barrel of daily throughput

WHY PETRECO LUBE TREATING DOES A BETTER JOB

1 **Petreco Lube Oil Treating outmodes conventional treating systems,** such as batch and centrifugal. It is automatic, precision-controlled, continuous. Petreco Lube Oil Treating changes lube treating from an "art" to a *science.*

2 **Petreco Lube Oil Treating eliminates guesswork.** It eliminates the problems and uncertainties of gravity settling. It eliminates the high equipment cost and maintenance headaches of centrifugal treating. It incorporates the many advantages of automation. Because the lube stock is *intimately* contacted with acid, less acid is used, and is *made to work harder.* Intimacy of contact is possible with Petreco because all the elements in the treatment—temperature, pressure, amount of acid, degree of mixing intensity, and contact time—are predetermined and automatically controlled. The acid-lube oil contact time is precise because, with Petreco, separation is "right now".

FIELD PROVED

Petreco Lube Oil Treaters are currently in use by two of the largest refiners in the United States. Reported advantages of Petreco Lube Oil Treating are:

1. Continuous
2. Automatic
3. Minimum Contact Time
4. Lower Acid Requirements
5. Re-use of Acid Sludge
6. Oil Not Exposed to Atmosphere
7. Sludge Can Be Pumped
8. Negligible Oil Entrainment in Sludge
9. Minimized Sludge Disposal Problem
10. Low Operating and Maintenance Costs
11. Employee Training Simplified
12. No Air Pollution

Get better lube products, with less operating attention, low capital investment, minimum operating cost . . . get Petreco.

Write today for the Petreco Lube Oil Treating Booklet. Complete information is yours for the asking.

PETRECO

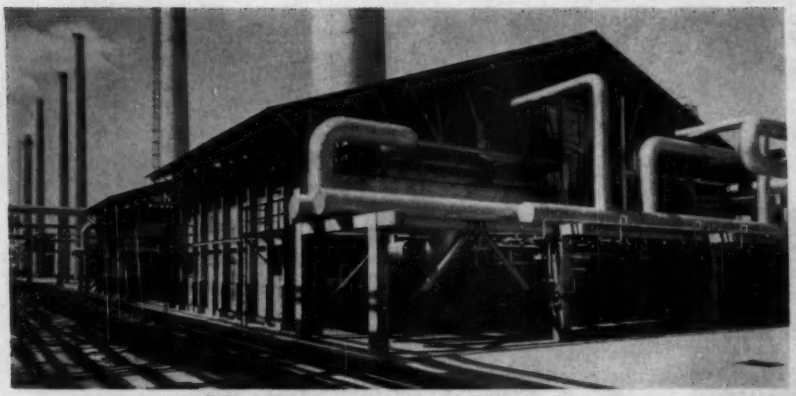
A DIVISION OF PETROLITE CORPORATION

3202 SO. WAYSIDE DRIVE, HOUSTON 1, TEXAS • 1390 E. BURNETT STREET, LONG BEACH 7, CALIF.

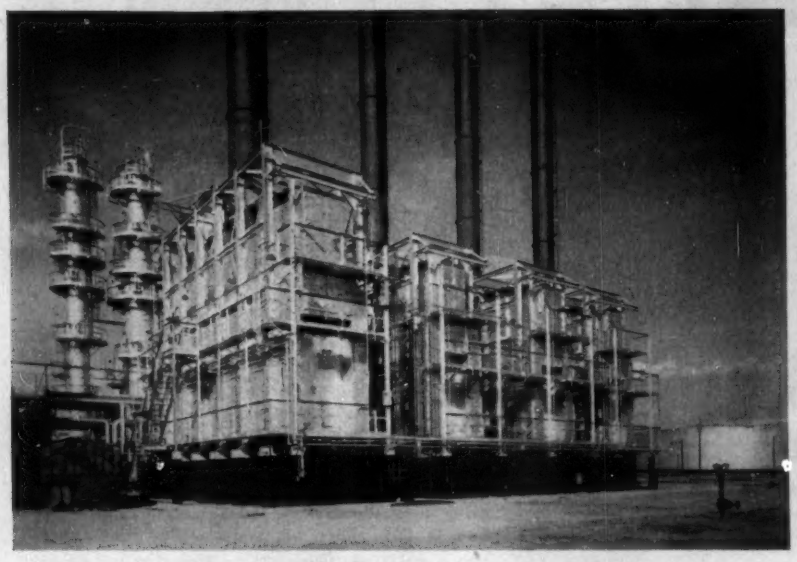
Specialized Petroleum Treating Processes and Equipment—DESALTING • DEHYDRATING • DISTILLATE TREATING SWEETENING • LUBE OIL TREATING • SEDIMENT REMOVAL

DT 58-4

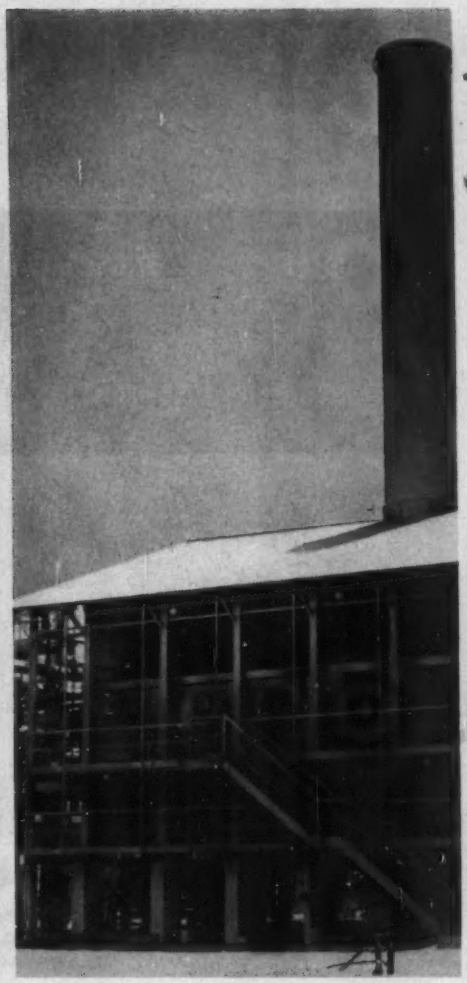
For more data on advertised products, use Readers' Service Cards, last page.



Reformer Heaters at Tidewater's new Delaware refinery.



Sovaformer Heaters at Magnolia Petroleum Company, Beaumont, Texas.



Thermofor Catalytic Reformer Heater at the Torrance, California refinery of the General Petroleum Corp.

HIGHER EFFICIENCY, LUMMUS OIL HEATERS

Lummus designs horizontal and vertical-tube oil heaters to any size, for any process—anywhere in the world.

Major refiners confidently turn to Lummus on their important and difficult oil heater jobs.

In the last 25 years, the combined capacity of all Lummus oil heaters built has exceeded that of any other company in the world. The reasons: greater durability, more efficient operation, an absolute minimum of days lost to downtime.

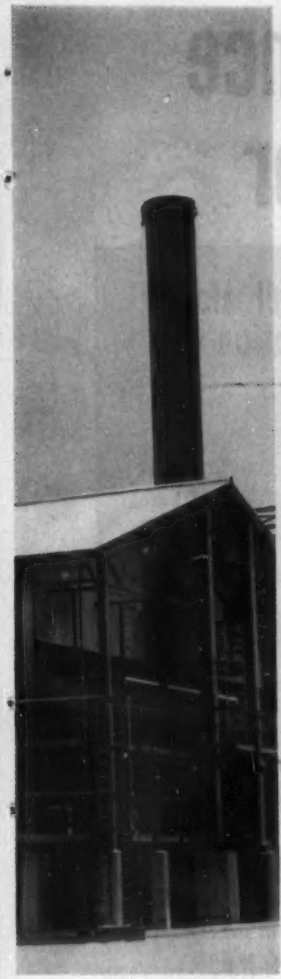
Major refiners maintain large engineering and economics staffs who can evaluate the performance of important heating equipment. They buy more Lummus oil heaters because they *know* through statistical comparison that Lummus gives them *more heater per dollar.*

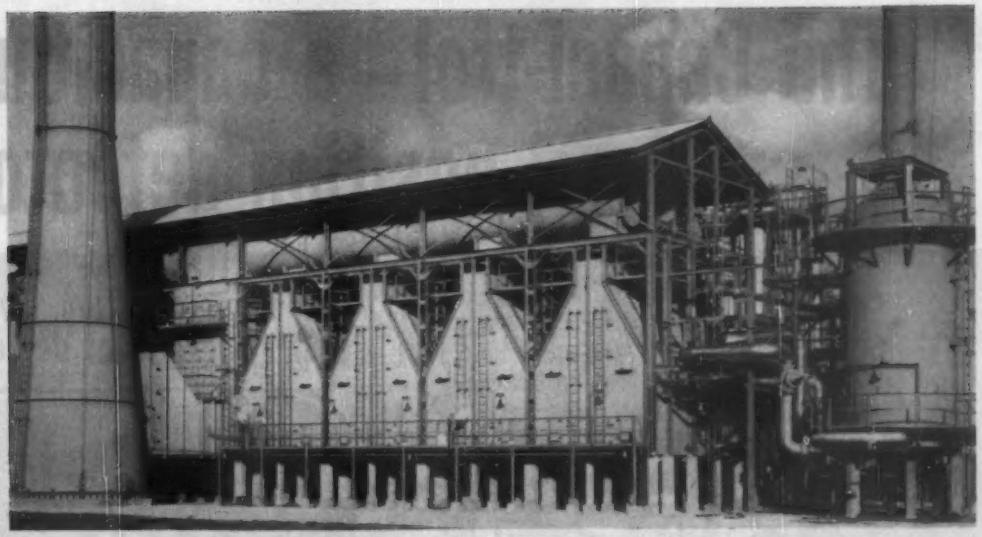
In 1957 alone, Lummus received contracts to engineer more than 130 oil heaters, with a combined absorbed-capacity of over 7,000,000,000 Btu per hour — the largest number of units and highest overall capacity in Lummus' oil heater history!

Lummus offers over a quarter of a century of oil heater experience for petroleum refineries, chemical and petrochemical plants. The highly trained engineering staff of the Oil Heater Division is ready in the Lummus New York office to give each job the full benefit of its accumulated know-how in this field.

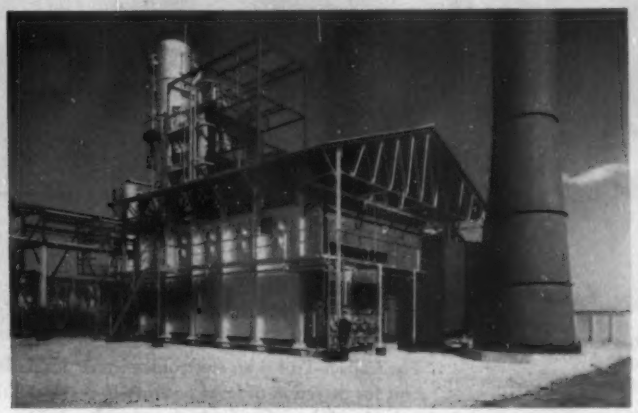
Lummus oil heaters, of both special and standard design, range from 100,000 to 300,000,000 Btu per hour. As illustrated above, neither size, type nor location of the unit presents a problem to Lummus. Because Lummus offers *every* type of oil heater,

For more data on advertised products, use Readers' Service Cards, last page.

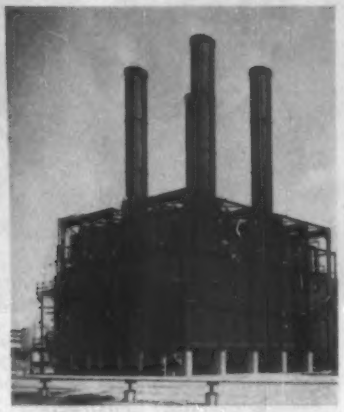




Ethylene Heaters for the National Petro-Chemicals Corporation at Tuscola, Illinois.



Topping and Vacuum Heater at the Suntide Refining Co., Corpus Christi, Texas.



Heater for 100,000 B/D atmospheric distillation unit for Gulf Oil Corp. at Port Arthur, Texas.

MINIMUM DOWNTIME MAKE PREFERRED AMONG MAJOR REFINERS

you can be sure that we will recommend the *right* unit for your needs. Complete Lummus facilities are available world-wide through any of the five international Lummus companies. Equipment is designed in New York, procurement is made through the nearest Lummus international office, and the cost of the job is payable in the currency of the country in which the procurement is handled!

Consult with Lummus on your next oil heater — large or small.

LUMMUS

THE LUMMUS COMPANY, OIL HEATER DIVISION
385 MADISON AVENUE, NEW YORK 17, N.Y.

WASHINGTON, D.C. • CHICAGO • HOUSTON • MONTREAL • CARACAS • MARACAIBO • LONDON • PARIS • THE HAGUE

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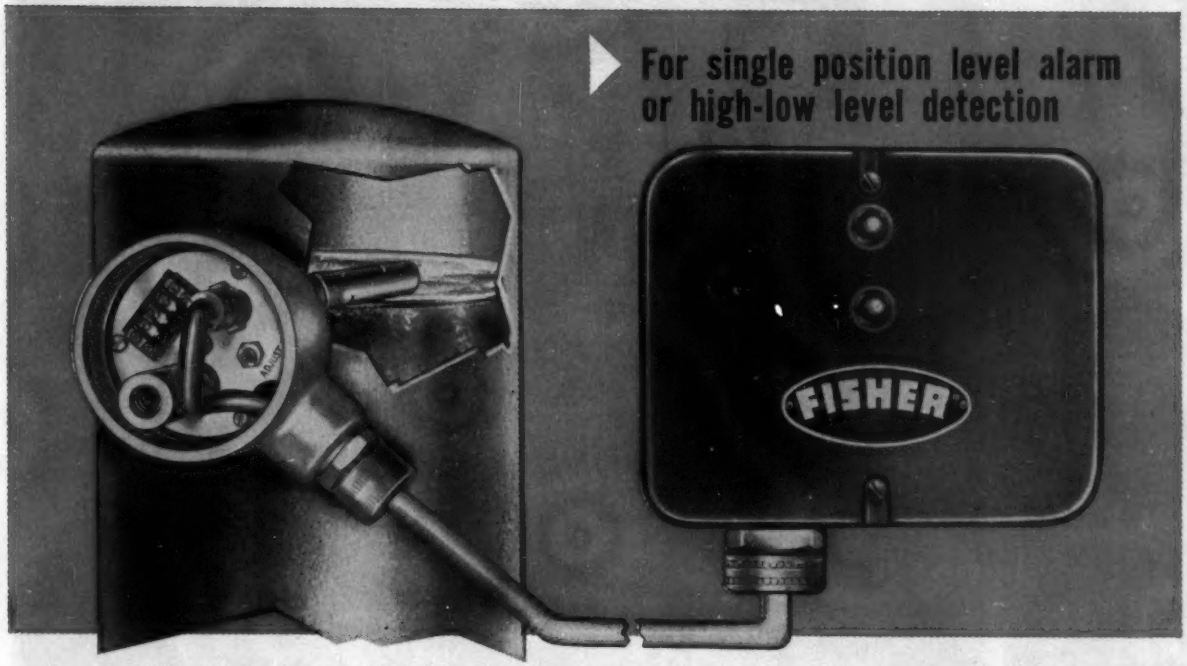
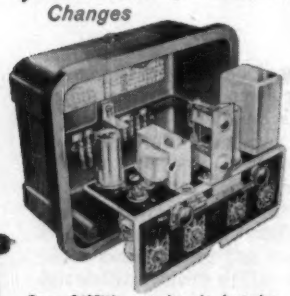
The Capaci-trol—a capacitance type level position detector



Type 2414W with sensing element installed horizontally for high level detection.

- *Compact Construction*
- *No Moving Parts*
- *Pressures up to 2500 psi*
- *Requires only 110 a. c. to operate*
- *Unaffected by Supply Voltage Variations*
- *Temperature Application Range From —50° F. to +150° F.*
- *Unaffected by Ambient Temperature Changes*

The Capaci-Trol is an electronic-electric level alarm and control unit for detection of level position in vessels—either as single point level detection for high or low level alarm applications or for high-low differential gap level detections. Units operate with power frequencies of 60 cycles utilizing a capacitance bridge circuit in conjunction with a rugged and durable Thyratron tube. Requiring only 110 a. c. supply voltage, the Capaci-Trol is completely self-contained and has no moving parts. The electrical output can be used to operate solenoid valves, motor starters, indicator lights, alarms, etc. All components of the Capaci-Trol are of the highest quality available, insuring maximum dependability and long life.



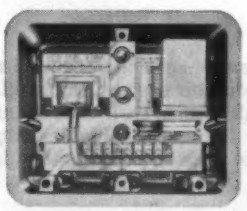
Type 2408W control unit featuring plug-in chassis.

AVAILABLE IN TWO MODELS

TYPE 2408W DIFFERENTIAL GAP CONTROLLER. The Type 2408W can be used in a wide range of conducting liquids for two-position control of level. Components are mounted on a plug-in chassis housed in a weather-proof aluminum case. Sensing elements available in lengths from 6" to 36" which is connected to remote control unit with coaxial cable. Maximum differential gap—80% of total length of sensing element. Minimum differential gap—0.5".

TYPE 2414W HIGH OR LOW LEVEL ALARM. The Type 2414W High or Low Level Alarm unit, as shown above, is designed for use in both conducting and non-conducting liquids. This, in general, includes the range from aqueous solutions to petroleum oils. Weather-proof housings are used for all components. Thyratron tube is in head portion of sensing element, thus requiring only standard wire in connecting to control case.

Write for Bulletin F-2408 for complete information



Type 2414W remote case contains power supply, relay and lights. Thyratron tube and level adjustment located in conduit on top of sensing element.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

FISHER® Controls

SINCE 1880

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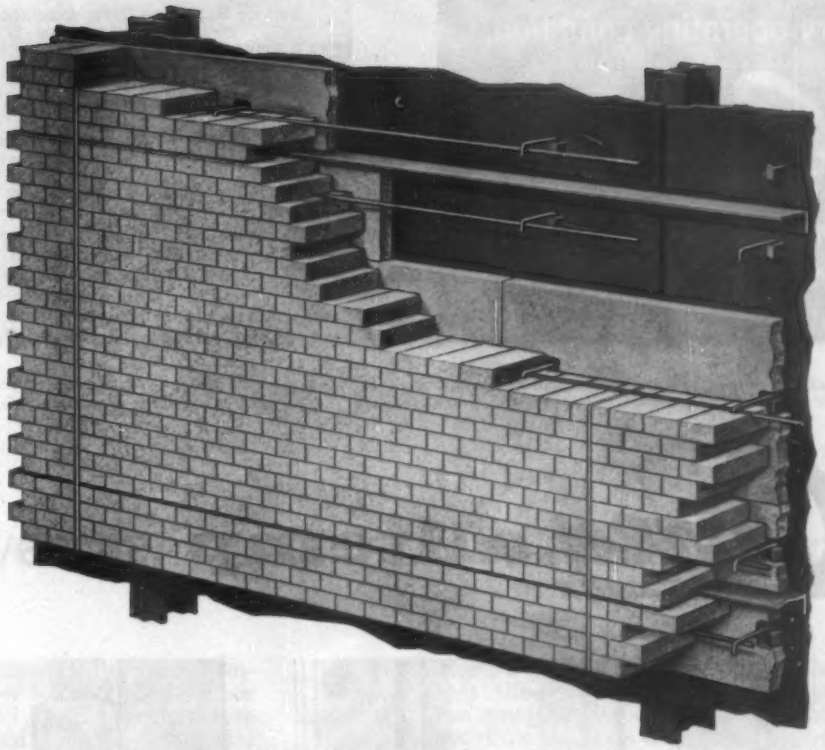

B&W Insulating Firebrick sectionally supported wall construction, horizontal rod-type anchoring

Can this construction cut your costs?

Simplified design and lower material costs in initial construction, ease of installation and maintenance, reduced downtime and economy of operation—these are the benefits of this *lightweight* insulating firebrick construction.

Here's what lightweight means. Compared with dense fireclay refractory materials that weigh from 125 to 140 lb per cu ft, lightweight insulating firebrick weigh approximately 26 lb per cu ft for B&W's 2000 degree brick. This difference provides two major advantages: (1) mechanical, which largely affects design and construction, and (2) thermal, which saves in maintenance, downtime and operation.

Savings in design and construction

The use of lightweight IFB simplifies engineering requirements and reduces costs. A minimum of detailing is needed, since the design is engineered around one standard shape — a feature of B&W IFB constructions.

Material requirements are simplified, too. B&W IFB can be tailor-cut, drilled or shaped as necessary, eliminating the need for costly special fired shapes, and the delays in obtaining them. Typical sections, such as burner openings, observation ports and tube supports, can be cut and shaped on the job in minutes, using ordinary woodworking tools.

Substantial savings are possible in structural steel, since insulating firebrick roof and wall constructions are lighter. In locations with soil of poor load bearing capacities, this lightweight may also result in reduced foundation costs.

These savings, coupled with B&W's engineering and service facilities available during the design phase, mean lower initial costs.

Savings in maintenance, downtime and operation

Lightweight IFB offer a major thermal benefit—they store and conduct less heat. Heavy refractories retain heat; in the event of forced shutdown, they can cause burn-out of expensive alloy tubes, where used. The low quantity of heat stored by B&W IFB can be quickly dissipated, thus protecting these expensive tubes.

Further, this low heat storage permits faster heating and cooling. This means quicker access to the furnace in the event of emergency shutdown. Your maintenance crew can get in the furnace sooner and get it back on stream faster.

Supplied from nearby warehouses

With the use of simplified IFB constructions, refractory repairs can be quickly and easily accomplished with standard shapes from a nearby warehouse. This eliminates costly delays in obtaining special shapes.

Anchoring devices, too, are simplified. Since there are no expensive special castings in B&W IFB constructions, carbon steel or low alloy rods can be used. These are generally available from any local steel warehouse.

Increased efficiency

Generally, the lighter a firebrick the better an insulator it is. Since B&W IFB are the lightest insulating firebrick made, they are the most efficient insulators. Per inch of thickness, B&W IFB provide more insulation than any other refractory material. The result is that for walls of equivalent thickness less heat is lost with B&W IFB. Casing temperatures are lower, thus improving working conditions. This means increased efficiency and reduced operating costs.

R 838

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

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for every temperature range—
for every operating condition

Carey®

SERVICE-PROVED
INSULATIONS

Service Report on Carey Insulations at:

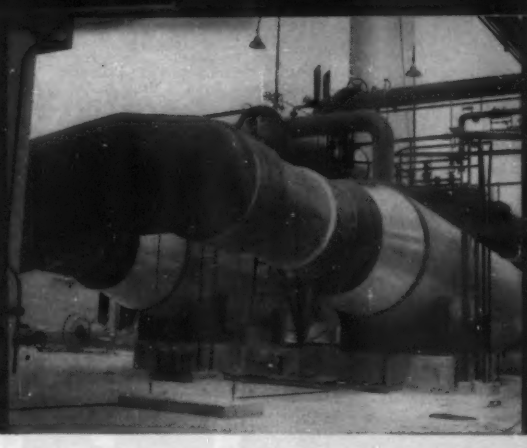
TEXAS BUTADIENE & CHEMICAL CORPORATION

Channelview, Texas

GENERAL CONTRACTOR: The Fluor Corp., Ltd.
INSULATION CONTRACTOR: B&B Engineering & Supply Co.

The Texas Butadiene chemical plant is the first completely new butadiene facility built since World War II. It is entirely an outdoor installation. Excepting turbines, all equipment (including 75 miles of piping) is exposed to the weather. Normal plant operation requires 30,000,000 cu. ft. of gas per day, with a heating value of 850 BTU per cubic foot. The company's primary products are butadiene, used in making synthetic rubber, and high octane aviation gas.

Carey® alltemp saves construction



5" thick Alltemp helps conserve heat used to make steam from these two waste-heat boilers. Operating temperature: 1150°F.

This horizontal hydrocarbon drum is insulated with a 2" thickness of Carey Alltemp. Operating temperature is approximately 400°F.

time and inventory costs at new Texas plant

The climate is mild in Channelview, Texas. Temperatures seldom dip below freezing (5 days per year on the average)—and during much of the year extremely high humidity brings continual rain. These were the conditions that Texas Butadiene faced when construction started on the company's new "open air" chemical plant. In February 1957 the plant began operation, with Carey Alltemp as the basic insulating material for all piping and equipment over 400°F. Here's what Texas Butadiene's Chief Engineer, T. H. Pierson, had to say about Alltemp's performance during the 18 month construction period:

"Carey Alltemp does not readily absorb water or moisture. Wherever possible, Alltemp was used in combination with Carey Weatherproof Jacketing. This assured us of a minimum delay in construction time, in the event of recurring rains. Workers were able to begin applying more insulation as soon as the rain stopped."

Reductions in plant maintenance inventories and storage requirements were other factors that influenced Alltemp's selection, according to Mr. Pierson. "Since Alltemp can be used for all temperatures from ambient to 1600°F., the necessity of stocking two different kinds of material to cover medium and high temperature applications was eliminated. Now, one insulation does both jobs—saves us storage space and inventory costs.

"And Alltemp is a relatively clean material to work," Mr. Pierson added. "It's unusually tough, too, for a molded, high temperature insulation. These two properties cut construction time still further by reducing the number of hours spent in cleaning up the work site."

With Texas Butadiene's new plant in full operation, Carey Alltemp is now performing its most important service—helping produce the steam that drives the plant's power equipment. And Alltemp is performing this service under what may well be the country's toughest moisture conditions, and at operating temperatures that often exceed 1100°F. Truly another success story for *industry's only all-purpose insulation!*

◀ Part of the plant's 75 miles of piping can be seen in this view of the pipe rack. Temperatures in the various lines range from 150° to 750°F. Pipe covering is Carey Thermoglas (up to 350°F.) and Alltemp (350°–750°F.).

Better Products for Industry Since 1873

THE PHILIP CAREY MFG. COMPANY

Lockland, Cincinnati 15, Ohio

The physical characteristics of Carey insulation products are measured and tested with scientific precision by Mellon Institute of Industrial Research, Pittsburgh, Pa. This is your assurance of the accuracy of Carey product specifications. Mail coupon for literature and sample specifications, or write for the name of your Carey Insulation Sales Representative.

THE PHILIP CAREY MFG. COMPANY, DEPT. PR-38
Lockland, Cincinnati 15, Ohio

Please send literature and sample specifications on

☐ Alltemp ☐ Thermoglas

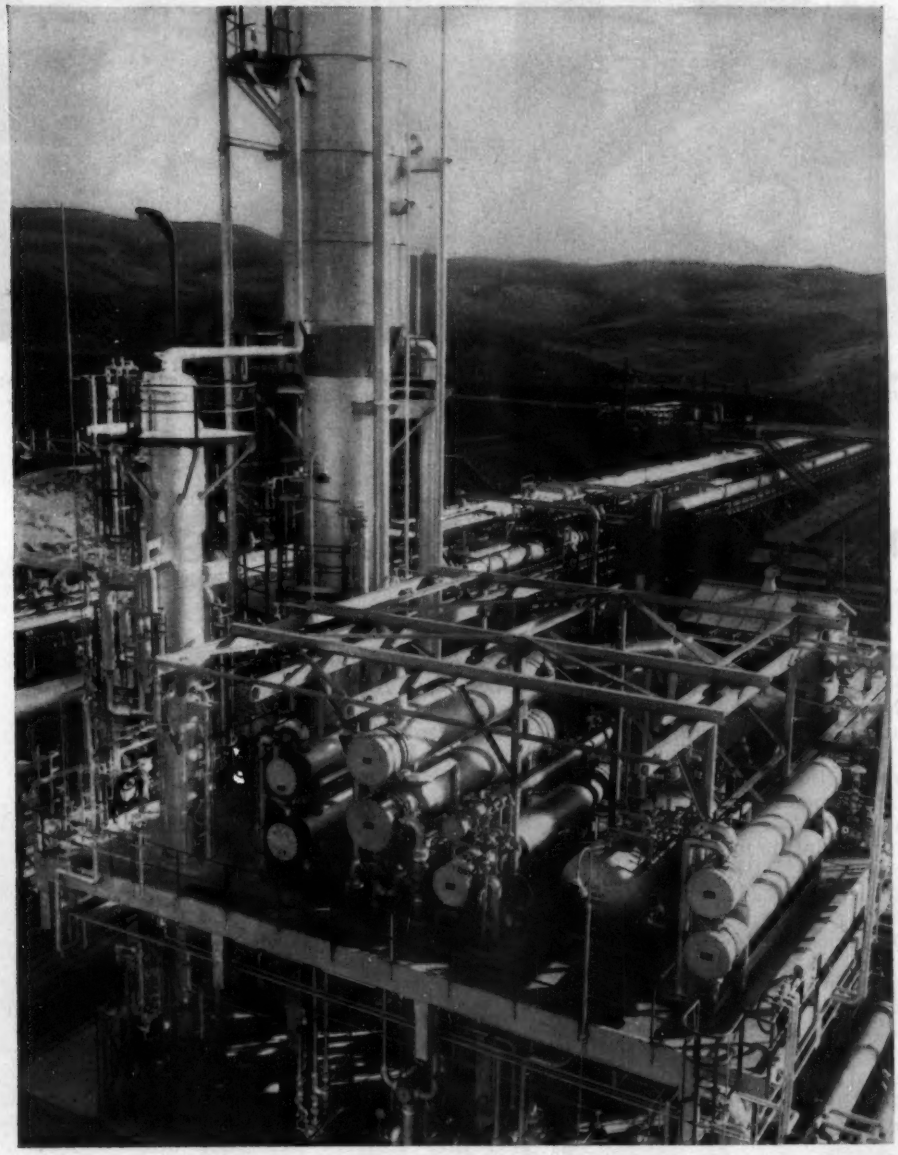
☐ Please have Insulation Sales Representative call.

NAME _____ TITLE _____

FIRM NAME _____

ADDRESS _____

CITY _____ ZONE ____ STATE _____



Oleum Refinery, Union Oil Company, California. Large topping column is of stainless steel with stainless trays and caps. Smaller stripping column and heat exchangers are of carbon steel. Diameters of exchangers range up to 36".

ON STREAM AT UNION OIL

YUBA ENGINEERED EQUIPMENT

What Yuba has done for Union Oil it can do for you... design and manufacture a *SINGLE UNIT* or equip an *ENTIRE SECTION* of a processing plant.

Yuba is geared to furnish heat exchangers, columns, towers, storage tanks, pressure vessels, expansion joints, and structural fabrication.

In the design of Yuba equipment many unique features have been incorporated. For example, Yuba heat exchangers for high temperatures and pressures feature the famous Multilok closure and welded tubes.

Plants conveniently located in East and West. May we have your inquiry?

YUBA CONSOLIDATED INDUSTRIES, INC.

351 CALIFORNIA STREET, SAN FRANCISCO 4, CALIFORNIA

Divisions Manufacturing Heat Exchangers
ADSCO DIVISION, BUFFALO, N. Y.
CALIFORNIA STEEL PRODUCTS DIVISION, RICHMOND, CALIF.
YUBA HEAT TRANSFER DIVISION, HONESDALE, PA.
YUBA MANUFACTURING DIVISION, BENICIA, CALIF.

YUBA

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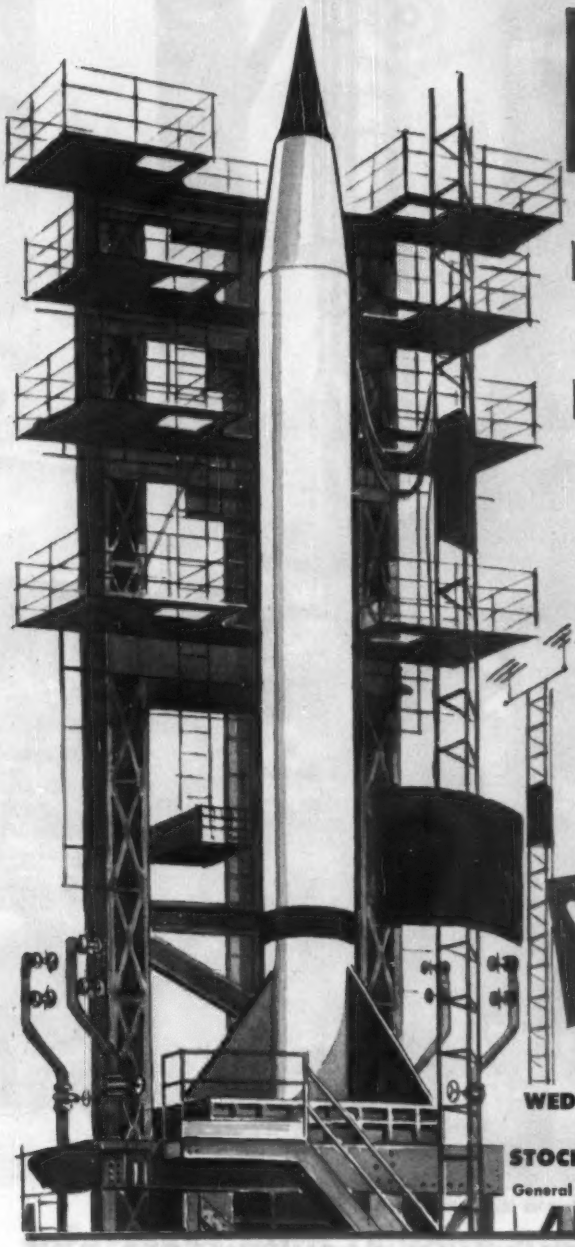
THE VALVE WITH A FUTURE



▶ In the CHEMICAL INDUSTRY

▶ In the MISSILE INDUSTRY

The design of Wedgeplug Non-Lubricated Steel Plug Valves and their precision manufacture assure quick, easy, dependable operation; and, *absolute shut-off* at both low and high temperatures.

WRENCH OPERATED
HANDWHEEL OPERATED
WORM GEAR OPERATED
MOTOR OPERATED

WEDGEPLUG
NON-LUBRICATED
STEEL PLUG VALVES

For Complete Catalog Information Write to DEPT. M Box 2592

WEDGEPLUG VALVE COMPANY
Division of
STOCKHAM VALVES & FITTINGS
General Offices and Plant, Birmingham 2, Ala.

- Wedgeplug Valves are in use on Rocket Test Stands and Launching Pads.
- Carbon Steel and Alloy Steels.
- Service: Liquid and Gaseous Oxygen, at -300° F; Liquid and Gaseous Nitrogen; Jet Fuels.

SOLD THROUGH DISTRIBUTORS
IN EVERY MAJOR CITY

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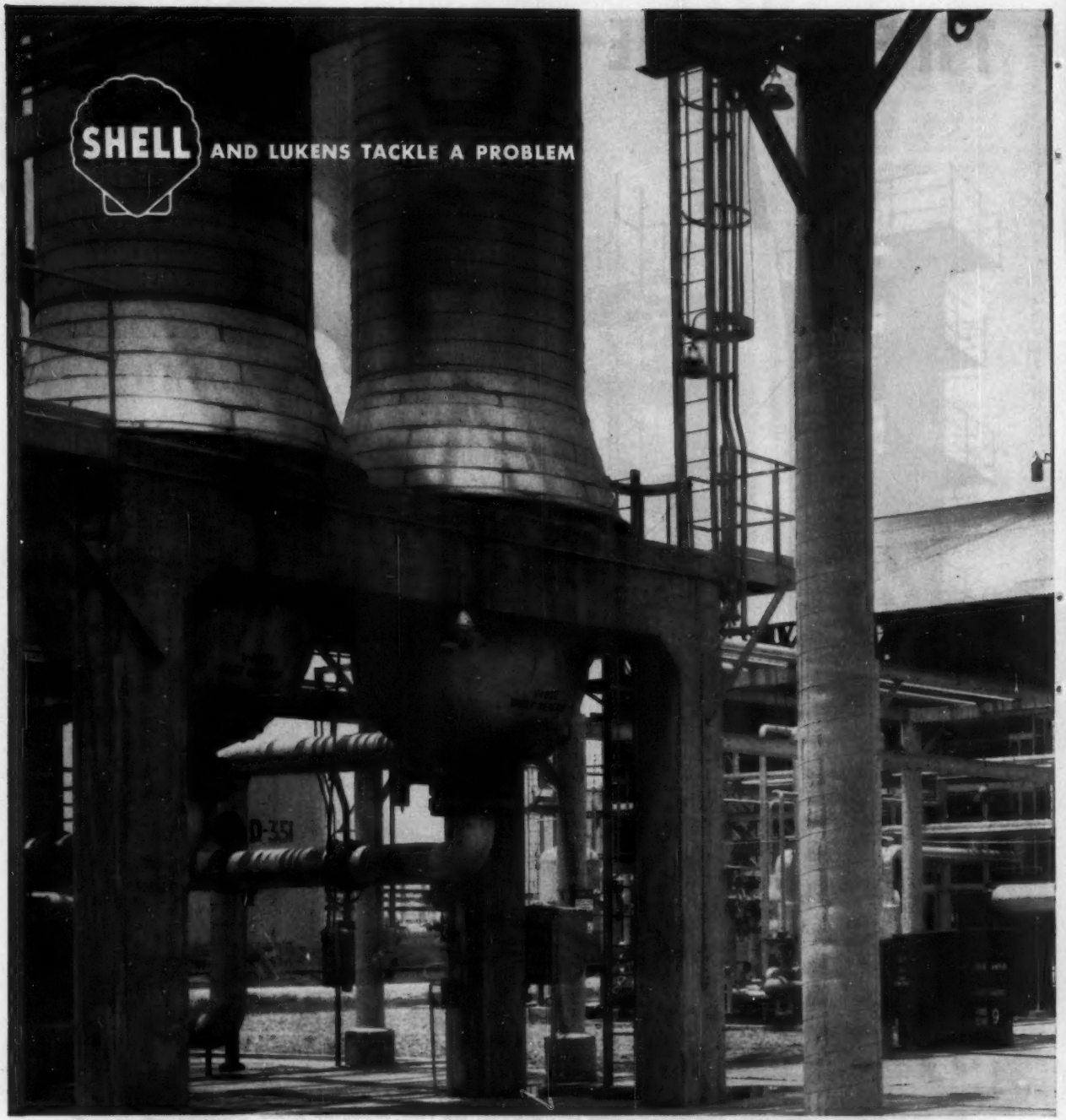

Two 78" diameter Shell Vapor-Phase Hydrodesulfurizer reactors fabricated with Lukens stainless-clad steel.

Teamwork pays off—designing desulfurizers and

Flued hemispherical heads answer need for uniform stress patterns

It took teamwork between Lukens and Shell . . . and at this modern Houston, Texas, refinery the results are rewarding.

There were separate problems in selecting steels for the Shell V-P Hydrodesulfurizers and Platformers and a common problem of obtaining a more uniform stress pattern in heads of both.

In the 78" diameter V-P Hydrodesulfurizer reactors, Lukens stainless-clad steel with a backing of Lukens A-204 firebox steel provided the required high resistance to hydrogen and hydrogen sulfide attack at elevated temperatures, plus strength and protection against hydrogen embrittlement.

In the 60" diameter Platformer reactors, where design pressure is 800 psi and design temperature is 950 deg. F., Lukens chrome moly steel plate gave still greater strength-temperature handling ability, plus resistance to hydrogen attack.

And by the use of Lukens hemispherical spun and flued heads in both the V-P Hydrodesulfurizer and the Platformer, engineers and production men

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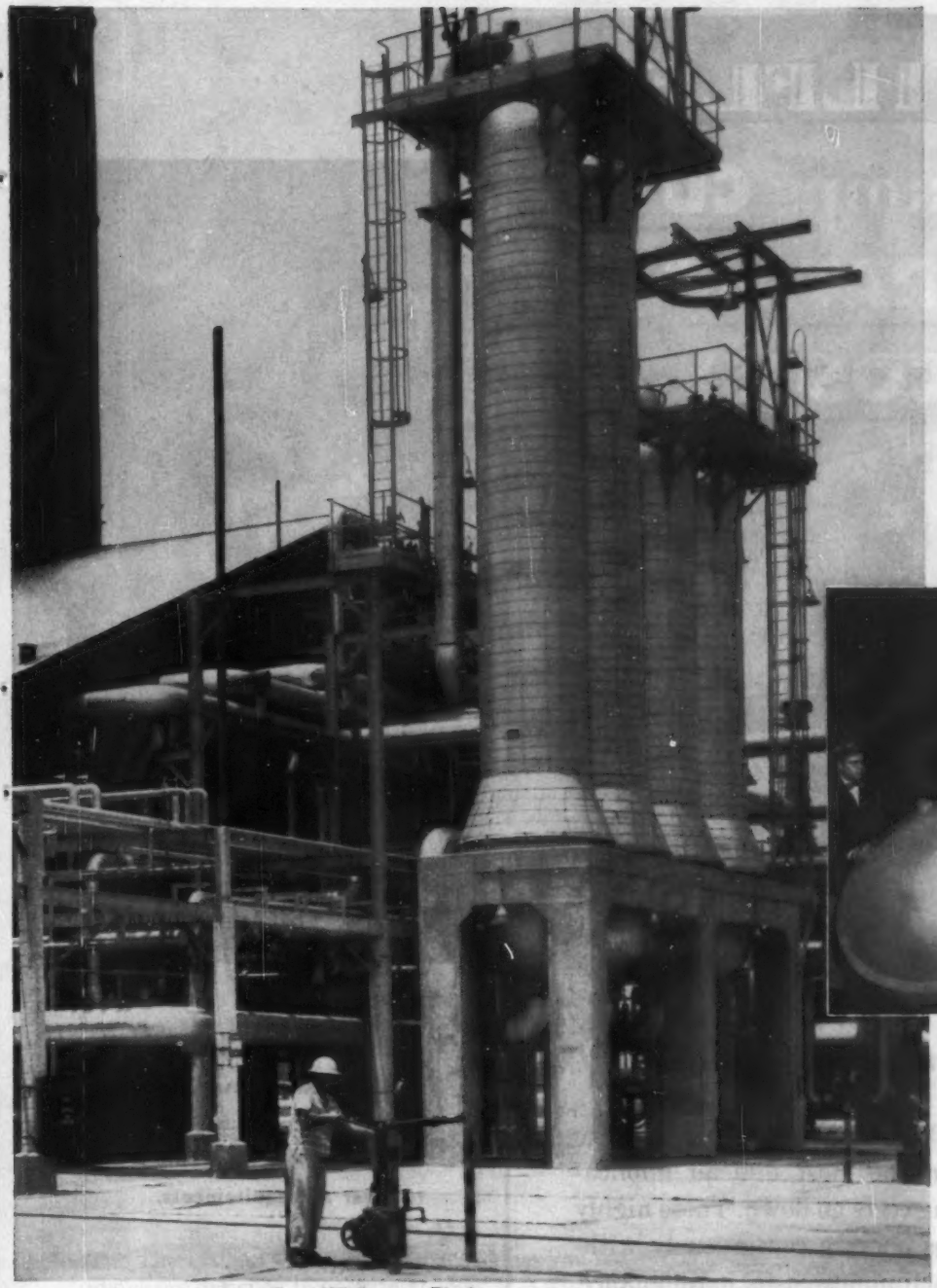

Four 60" diameter Platformer reactors of Lukens chrome moly steel.

Visit us at the

N.A.C.E.

Show in San Francisco, March 18 through 20. Our booth number is 35-37.

Smooth contours and accurate location of the flued openings in these Lukens spun heads matched Shell's critical design needs.

reformers with Lukens clad and alloy steels

achieved an outstanding advantage: Uniform stress patterns in the critical flued areas with added assurance of maintenance-free operation at high temperatures and pressures.

Ask your equipment builders about the broad range of Lukens clad, alloy, and carbon steels, or write for "CLAD STEEL EQUIPMENT." Address Manager, Marketing Service, Room 125, Lukens Steel Company, Coatesville, Pa.

This is Lukens clad steel—a solid plate—one side corrosion resistant metal permanently bonded over-all to a rugged, economical backing steel.

LUKENS

Helping industry choose steels that fit the job

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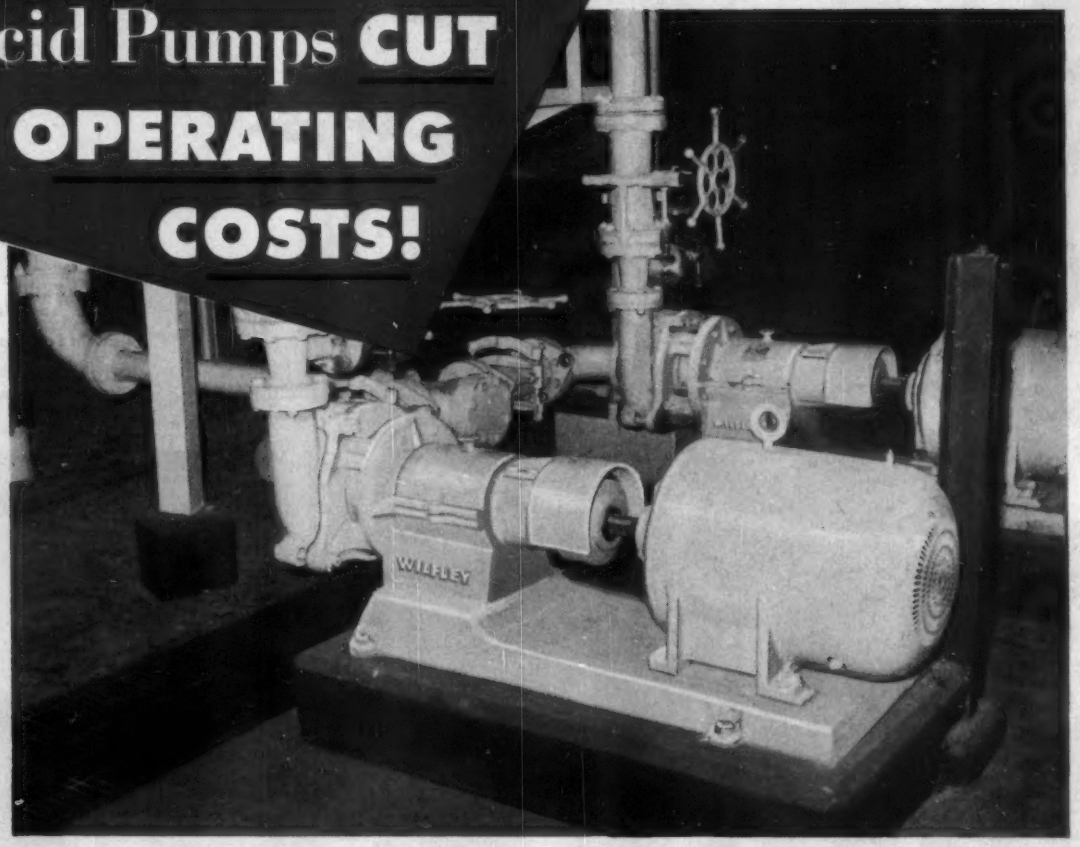
WILFLEY
Acid Pumps CUT OPERATING COSTS!



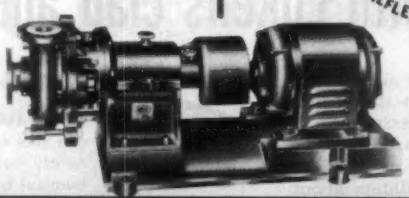
The reason... Dependability

Whenever Wilfley Acid Pumps are put to work, even on the most difficult applications, operating costs go down. These highly efficient pumps operate continuously without attention—eliminate costly maintenance. Wilfley dependability will save you money. Write, wire or phone.

Individual Engineering
ON EVERY APPLICATION

Wilfley Acid Pumps are available with pumping parts of the machinable alloys as well as plastic to meet all requirements.

WILFLEY ACID PUMPS
"COMPANIONS IN ECONOMICAL OPERATION"
WILFLEY SAND PUMPS

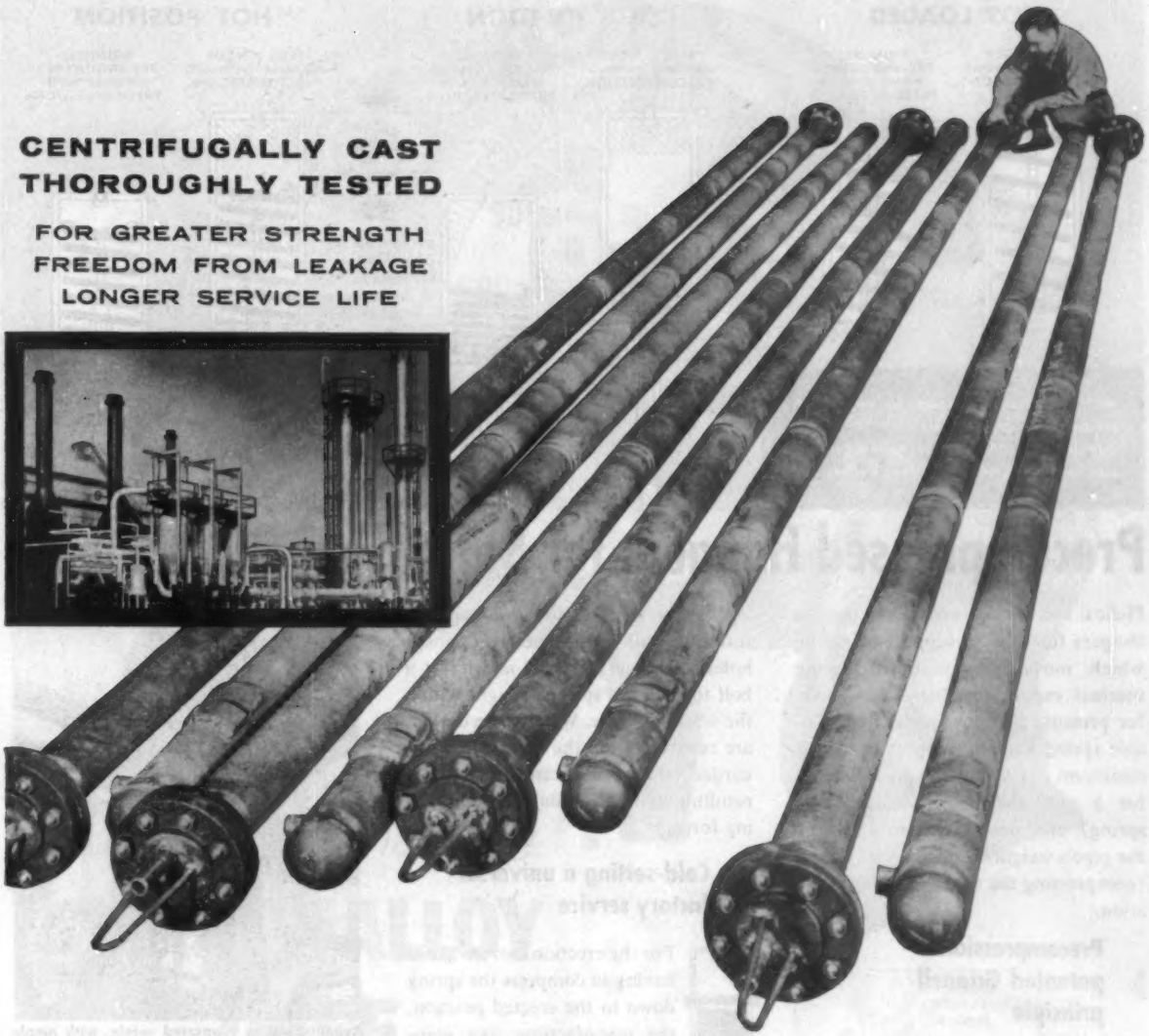


A. R. WILFLEY and SONS, INC.
DENVER, COLORADO, U.S.A. NEW YORK OFFICE: 122 EAST 42ND ST., NEW YORK CITY 17

For more data on advertised products, use Readers' Service Cards, last page.

CENTRIFUGALLY CAST
THOROUGHLY TESTED

FOR GREATER STRENGTH
FREEDOM FROM LEAKAGE
LONGER SERVICE LIFE



THERMALLOY
REFORMER FURNACE TUBES

The Thermalloy* Reformer Furnace Tubes you see above are designed to operate at 1820° F.—with internal pressure of 150 psig. To insure freedom from leakage and long service life, the individual cast tube sections underwent a hydrostatic test of 3000 psi. In addition, each assembly was tested at 900 psi.

Tube sections are centrifugally cast to specified diameters—to insure greater density, finer grain structure and uniform thickness. And experienced Electro-Alloys metallurgists and engineers can help you select the grade of high-heat-resistant Thermalloy best suited to your particular application.

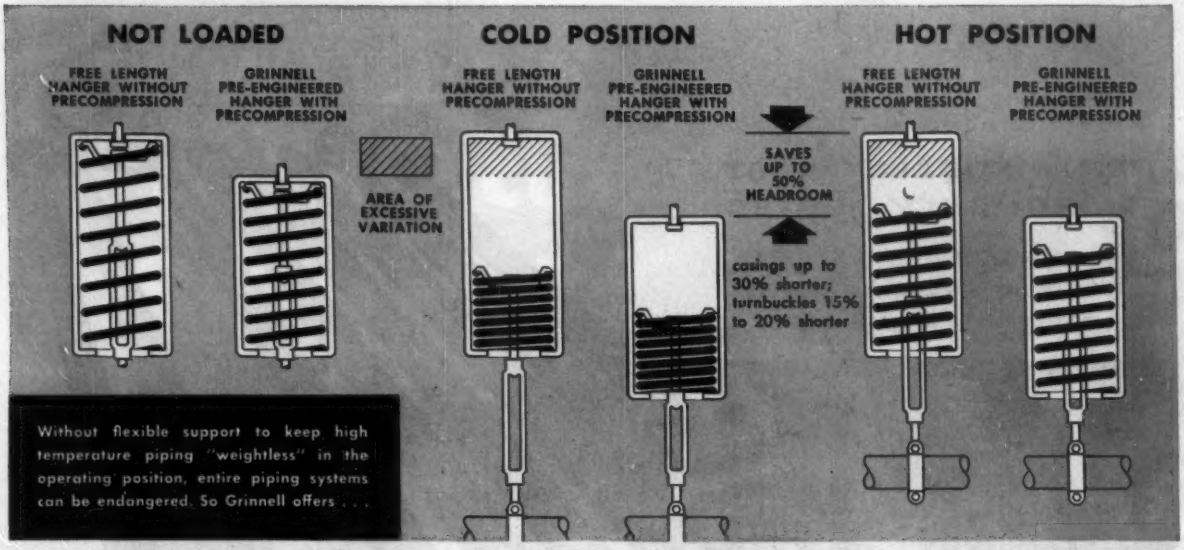
Recent expansion of Electro-Alloys' centrifugal casting facilities means we can meet your needs for Reformer Tube Assemblies promptly. Call your nearby Electro-Alloys representative. Or write for Bulletin T-283. Electro-Alloys Division, 9073 Taylor Street, Elyria, Ohio.

**Reg. U. S. Pat. Off.*

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION Elyria, Ohio

For more data on advertised products, use Readers' Service Cards, last page.


NOT LOADED
COLD POSITION
HOT POSITION
FREE LENGTH HANGER WITHOUT PRECOMPRESSION
GRINNELL PRE-ENGINEERED HANGER WITH PRECOMPRESSION
AREA OF EXCESSIVE VARIATION
SAVES UP TO 50% HEADROOM
casings up to 30% shorter; turnbuckles 15% to 20% shorter
Without flexible support to keep high temperature piping "weightless" in the operating position, entire piping systems can be endangered. So Grinnell offers . . .

Precompressed Hangers for Safer Support of Piping

Helical coil springs are widely used in hangers for flexible support of piping which moves up or down during thermal expansion. The A.S.A. code for pressure piping requires that variable spring hangers support at least a minimum of 75% of the pipe's weight for a pipe that rises (relaxing the spring) and no more than 125% of the pipe's weight for a pipe that lowers (compressing the spring) during operation.

Precompression patented Grinnell principle

To guard against the spring's supporting force exceeding the limits of variation, Grinnell developed and patented a variable spring hanger design. The steel casing holds the spring permanently precompressed, at the threshold of the hanger's working load range. This prevents the spring decompressing into its area of excessive variation.

Pre-set is not a substitute

As a partial substitute for this patented precompression, some manufacturers insert a spacer between the top end of a free-length hanger casing and the spring to hold the spring's height temporarily within the working range during shipment and erection.

Another device requires the manufacturer to drill symmetrically opposite holes in the casing walls and insert a bolt to hold the spring's height within the working range. When these devices are removed from the hanger and discarded, the spring can decompress, resulting in high variability in supporting force.

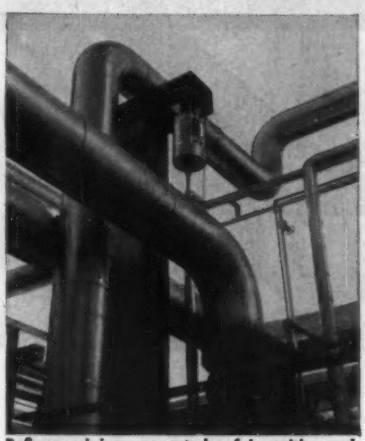
Cold-setting a universal factory service

For the erection crew to avoid having to compress the spring down to the erected position, the manufacturer can compress the spring down to this height. Grinnell can provide a cold-set bolt in precompressed hangers.

Less headroom required by Grinnell Hangers

Shorter hanger casings made possible by Grinnell's patented precompression, reduce bulk shipping weight and required headroom by eliminating undesirable height. Installation is simplified by this shorter casing and also by an integral load scale with load indicator.

Additional headroom is saved by a correspondingly shorter turnbuckle. These precompression advantages are available in short spring and double spring models as well as standard spring models.



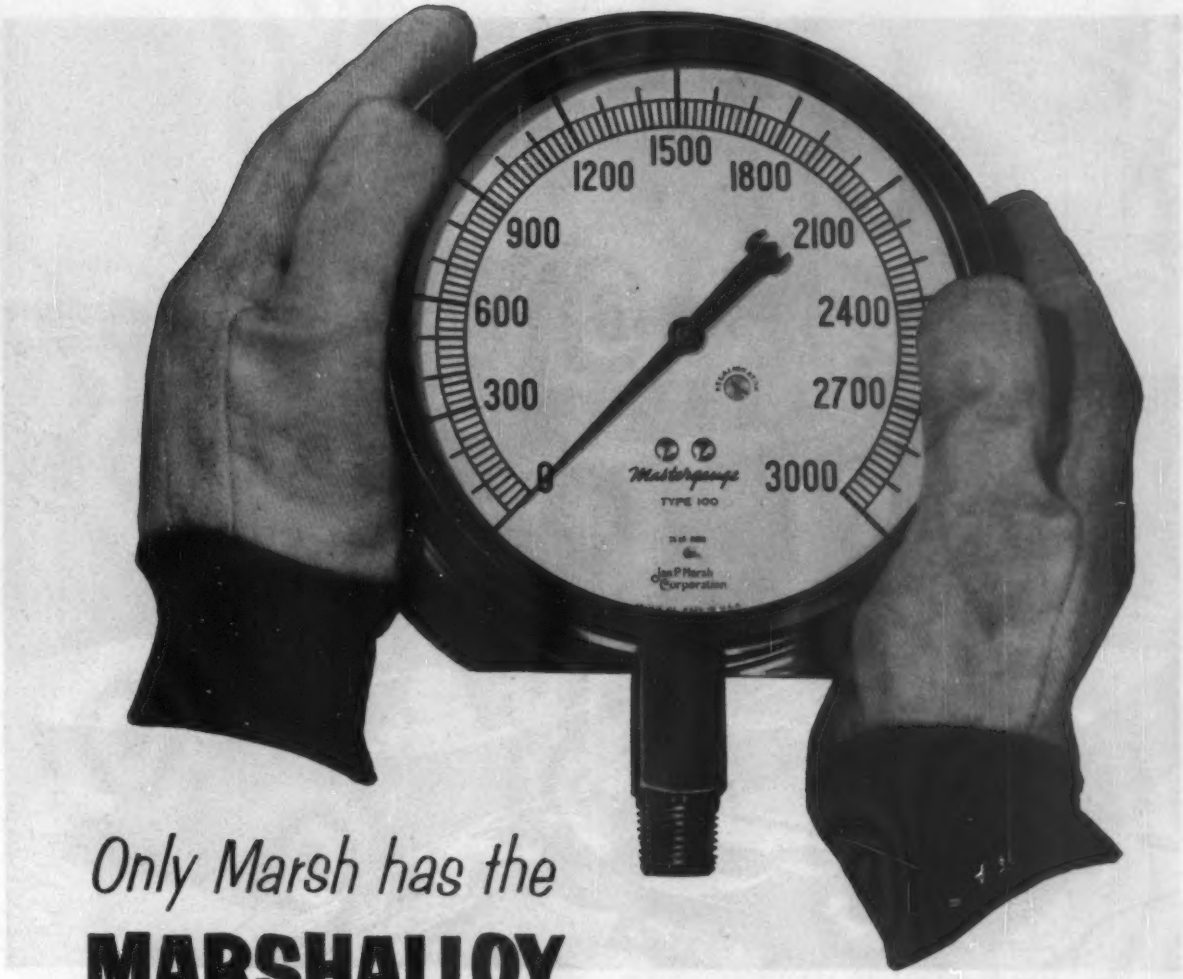
Refinery piping supported safely, with ample flexibility but low headroom.

Available in 63 standard units

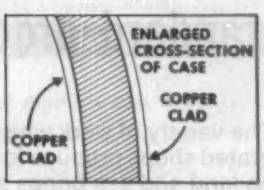
Grinnell Variable Spring Hangers are available in 21 sizes each of short, standard and double spring models . . . for maximum travel of 1¼, 2½ and 5 inches respectively within working load ranges. Load capacities extend from 43 lbs to 30,550 lbs. The maximum variation in the standard size per ½-inch deflection is 10½% of rated capacity; inversely proportional in short spring and double spring models.

For further information

If you have a pipe suspension problem, you are invited to write: — Grinnell Company, Inc., 282 West Exchange Street, Providence, R. I.



Only Marsh has the **MARSHALLOY CASE**



The strength of steel; the corrosion resistance of solid copper . . . that's the Marshalloy copper-clad case.

Four times stronger than cast iron
One-third lighter

There's nothing temperamental about a pressure gauge . . . provided it's built right and given proper protection. The basic units of Marsh Gauges—socket, tube and movement—are known for the care given to their manufacture. Such units deserve the best protection . . . and *get it* in the Marshalloy case. Here is a steel case of boiler-plate-thickness, heavily clad with copper inside and out . . . lighter, but many times tougher . . . protected against the ravages of corrosion. It is available only in Marsh Gauges.

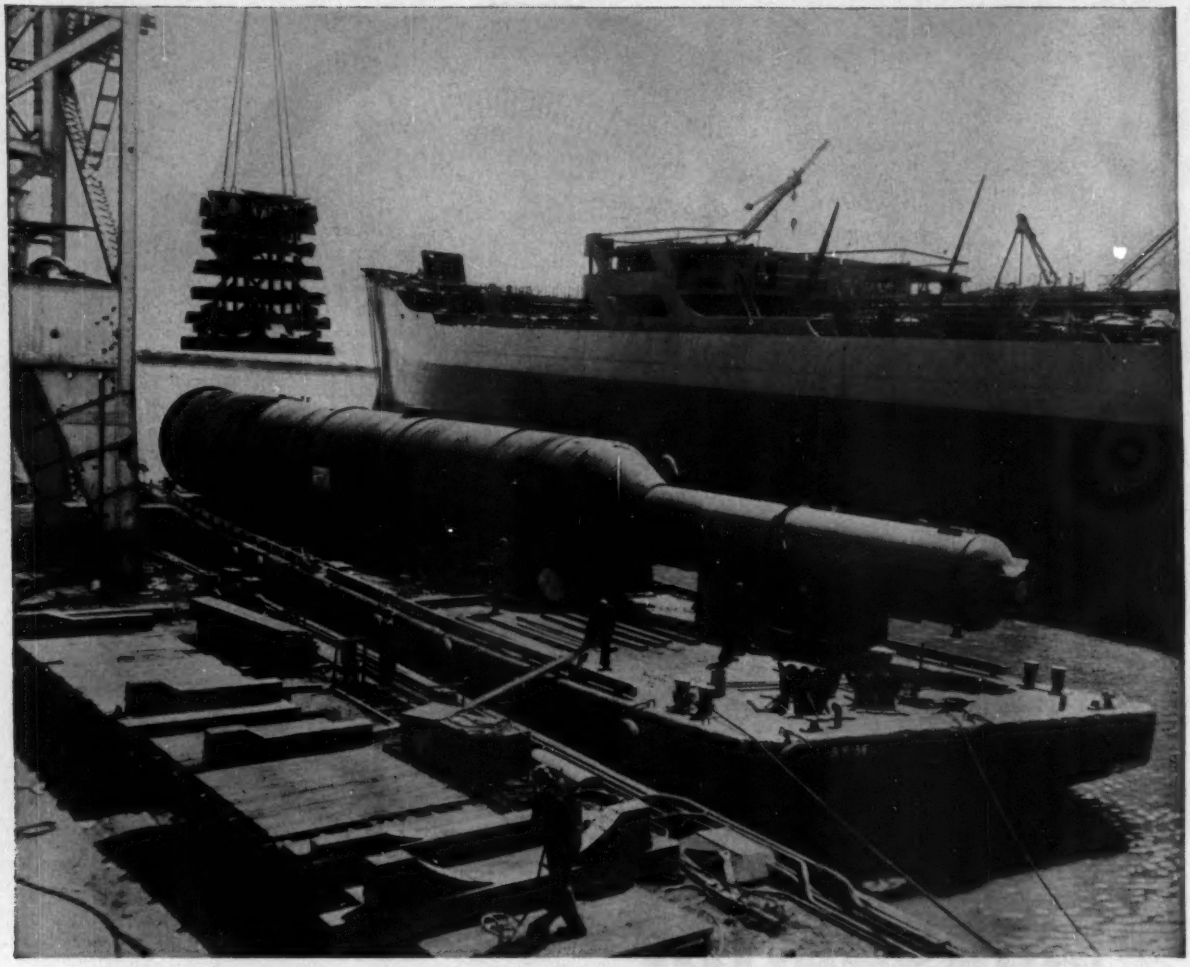
MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.*
Dept. R, Skokie, Illinois

Marsh Instrument and Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas

MARSH GAUGES

PRESSURE GAUGES • THERMOMETERS • WATER REGULATING VALVES • HEATING SPECIALTIES

For more data on advertised products, use Readers' Service Cards, last page.



standard procedure: VERSATILITY . . .

The variety of work which Sun Ship's integrated shops produce for use by industries on land and sea brings a matching variety of shipping problems.

Our facilities for tidewater shipment are used to economical advantage on many of the massive structures that go into the making of the nation's petroleum and chemical industries. The barge shipment of tower and shed row baffles, shown above, is a good example.

And of course—when shipment by land is necessary—Sun Ship rigging and routing find the ways and means to handle such items as large-diameter columns by rail and truck.

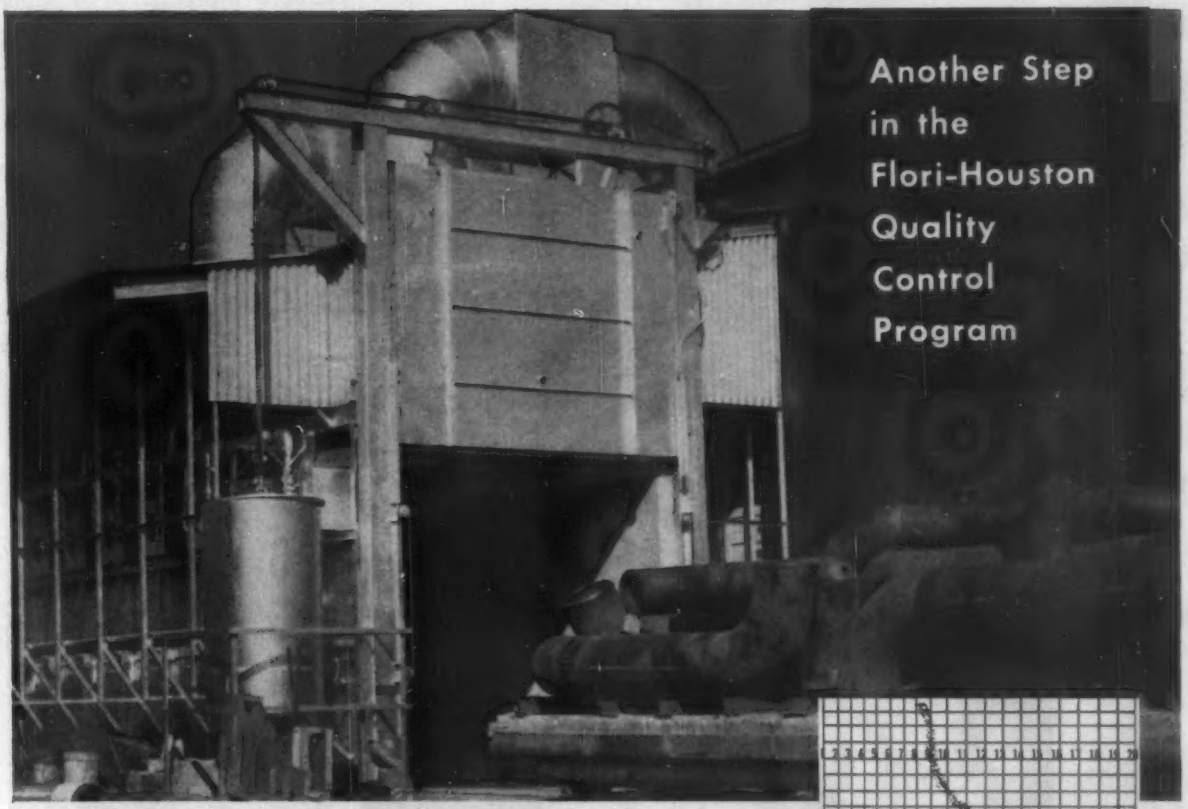
It's all a part of the versatility which forty years' experience has made part of "standard procedure" in service of its customers.

Our Sales Engineering Department would be glad to use its experience in helping you overcome any problem of construction or shipment that faces you. Write

Sun

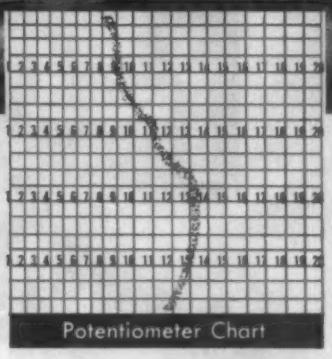
SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE SINCE 1916 **CHESTER, PA.**



FLORI-HOUSTON'S Custom Stress Relieving

means better pipe fabrication...


Potentiometer Chart

In this new 14-point heat controlled stress relieving furnace, all piping welds are stress relieved to your exact specifications. Temperature of the work during the carefully controlled heating and cooling cycle is checked continuously with as high as 12-point recording and controlling instrumentation. Furnace gas temperatures are zone controlled and recorded. Potentiometer Charts showing the exact heat treating cycles are always furnished assuring you of longer life and better performance from your piping.

GENERAL OFFICES

THE FLORI PIPE CO.

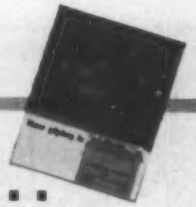
601 East Red Bud — St. Louis 15, Mo.

HOUSTON OFFICE

HOUSTON PIPE & STEEL, Inc.

P. O. Box 2, — Houston 1, Texas

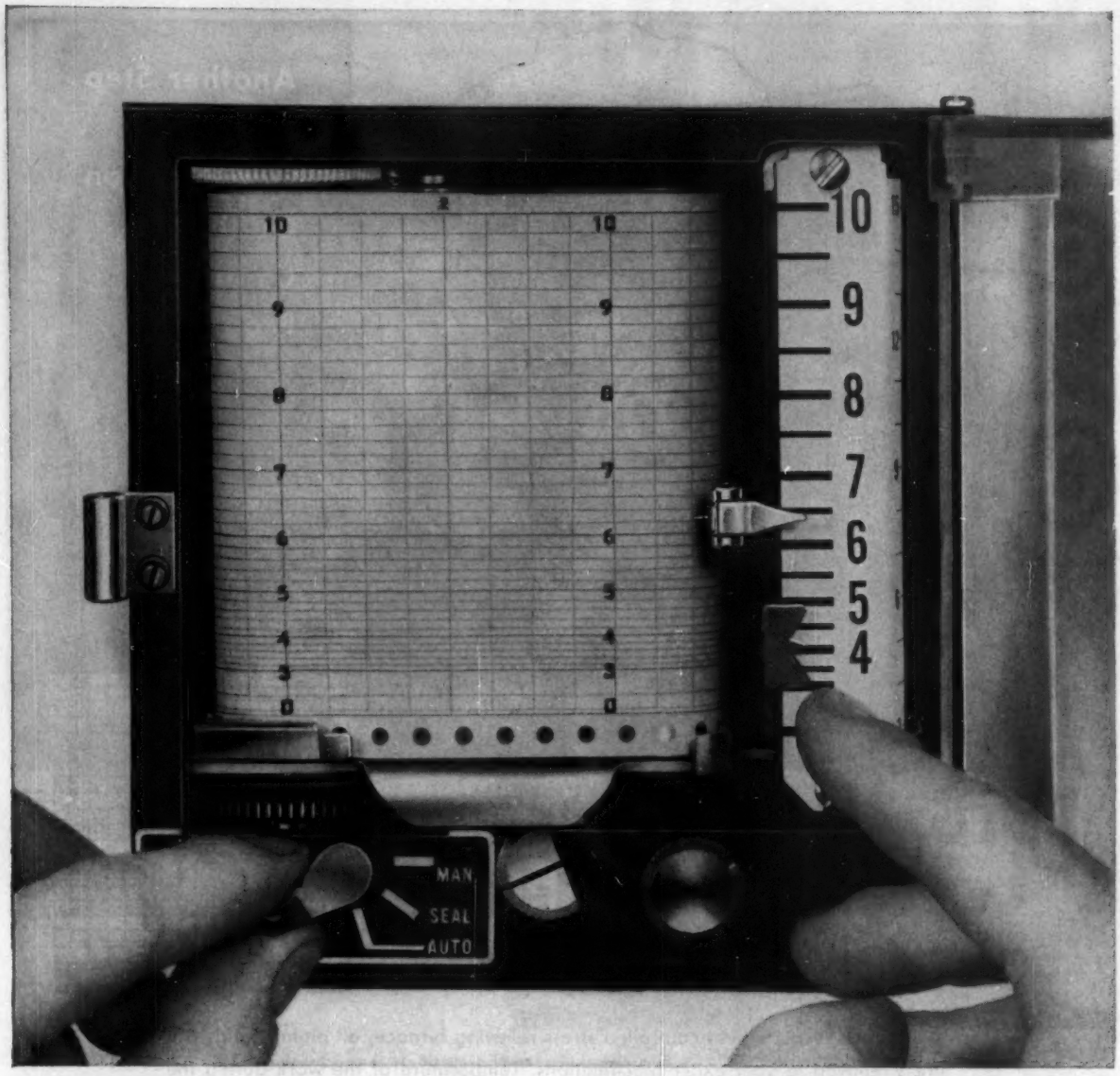
Subsidiaries of Sparton Corporation



FREE.....

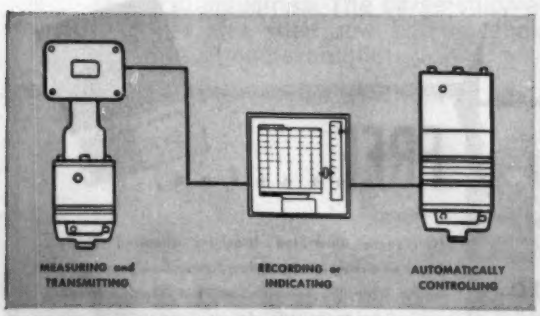
Handsome illustrated brochure showing Flori-Houston's complete facilities, fabrication processes, and outstanding examples of Flori-Houston fabrication jobs. Write today for your copy.

For more data on advertised products, use Readers' Service Cards, last page.

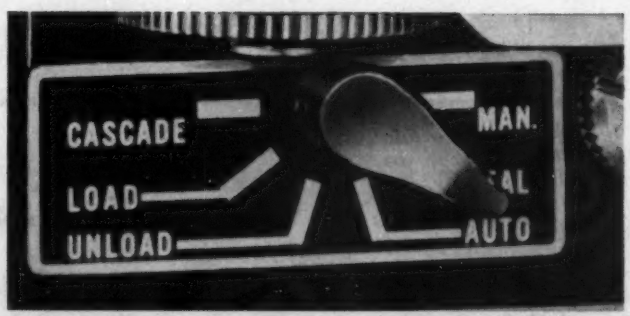


BRISTOL METAGRAPHIC RECEIVERS:

"Easiest 'bumpless



BRISTOL METAGRAPHIC INSTRUMENT SYSTEM

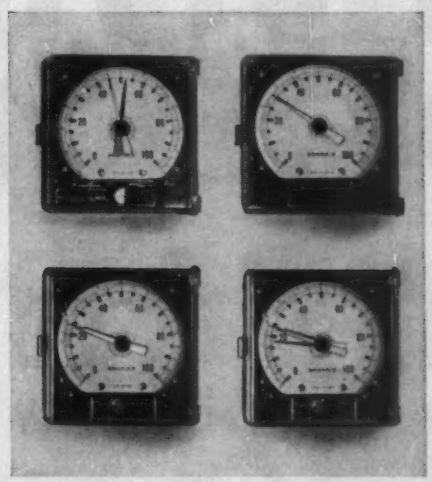


SIX-POSITION SINGLE-KNOB TRANSFER STATION (enlarged view) for cascade service. Three-position manual-automatic station is also available.

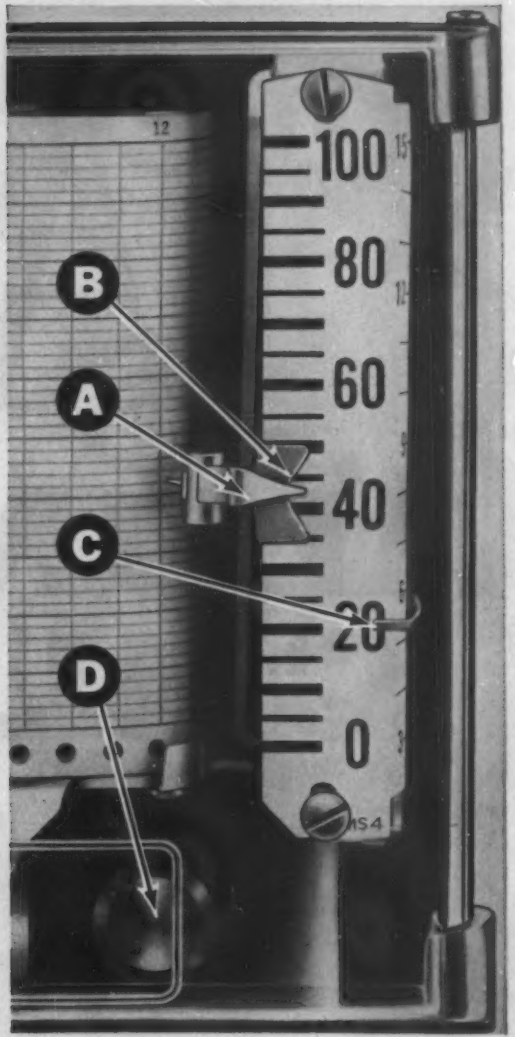
ONE OF 38 METAGRAPHIC RECEIVER MODELS you can choose from, all with 5" x 5¼" panel, all fitting into same 4 9/16" square panel cut-out. This Metagraphic Recording Receiver has single-knob six-position transfer station, gives easy start up and initial adjustment and completely "bumpless transfer" in complex cascaded control systems. Single-knob, six-position transfer station lets you select:

1. Completely automatic-cascade operation.
2. Automatic operation of slave loop alone.
3. Manual operation.

You get "bumpless transfer" both ways between all three conditions. This convenient switching greatly facilitates start-up of cascaded systems and initial adjustment of slave controller proportional, reset, and derivative actions.



METAGRAPHIC INDICATING RECEIVERS have full 9-inch scale for easy reading; feature: Complete 10-second interchangeability with recorders, show valve position as well as set point and controlled variable. Highly visible fluorescent paint on pointers makes deviation of set point and variable instantly apparent from as far as 20 feet away.



METAGRAPHIC RECEIVER shows measured variable (A), set point (B), and valve position (C), all on same scale. That's what makes manual-automatic transfer so easy, bumpless, and error-free with this instrument . . . just seal, match pointers with knob (D), transfer—that's all there is to it.

transfer' you ever saw"

That's what instrument men say after trying the Bristol Metagraphic Pneumatic Receiver—even in complex cascade control systems.

Just seal, match pointers, transfer. There's not a single value to read. It's that easy because the Metagraphic receiver gives you one-knob control plus continuous valve position indication on the same scale with set point and measured variable.

A genuine plug-in receiver. The Metagraphic is a *true* plug-in receiver—no finger-disconnects. *It plugs and unplugs in 5 seconds with no loss of automatic control. The case acts as a blind controller while the receiver is out.*

Don't pay for pre-installation errors. The Metagraphic's full plug-in versatility lets you switch from indicator to recorder in less than 10 seconds, interchange many receiver models, change recorder range simply by changing chart. Cuts down on costly reinstallations if process requirements are changed.

Write for the complete story on Bristol Metagraphic Receivers. Bristol gives you the widest selection of plug-in miniatures on the market—pneumatic, telemetering, electronic. (Full-sized instruments, too.) The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. 7.32

BRISTOL *TRAIL-BLAZERS IN PROCESS INSTRUMENTATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more data on advertised products, use Readers' Service Cards, last page.

$AlCl_3$

ALUMINUM CHLORIDE

The increasing use of Aluminum Chloride and the many new uses being found for it have led to a large increase in demand. In response to the need, Stauffer has increased production and refining capacity . . . is today, indeed, the country's largest producer.

PROMPT shipments of Anhydrous Aluminum Chloride are made from Houston, Baton Rouge and Elkton, Md., in drums of 600, 100 and 50 pounds net capacity.

Stauffer's Anhydrous Aluminum Chloride is made in granular or powder form, in six grades and numerous mesh sizes. Aqueous Aluminum Chloride is available on the West Coast only. Typical analyses of all grades of Stauffer's Aluminum Chloride comfortably surpass all specifications as to minimum $AlCl_3$ content, and maximum impurities.

Stauffer is also a major source of chlorides of Antimony, Boron, Silicon, Titanium and Zirconium. New book available on Metallic Chlorides; copies on request.

stauffer means service

Stauffer CHEMICALS SINCE 1885

STAUFFER CHEMICAL COMPANY

380 Madison Avenue, New York 17, N. Y.

Prudential Plaza, Chicago 1, Ill. • 636 California Street, San Francisco 8, Calif.

For more data on advertised products, use Readers' Service Cards, last page.

to all NATURAL GASOLINE MEN

GREETINGS

from the

NATURAL GASOLINE SUPPLY MEN'S ASSOCIATION

We are looking forward to seeing you at the

THIRTY-SEVENTH ANNUAL CONVENTION
of the NATURAL GASOLINE ASSOCIATION of AMERICA
APRIL 16-18, 1958, BAKER & ADOLPHUS HOTELS
DALLAS, TEXAS

Members of the Natural Gasoline Supply Men's Association

The Aber Company
Air Products, Inc.
Airetool Mfg. Co.
M. N. Aitken Company
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American Air Filter Co., Inc.
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Candoo Construction Co., Inc.
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Davison Chemical Co.
Dean Brothers Pumps, Inc.
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Delta Tank Mfg. Company
Dixie Iron Works
Dresser Engineering Company
E. I. duPont deNemours & Co., Inc.

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Eggelhof Engineers
John W. Elder Company
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Engineering Equipment Co.
Engineers & Fabricators, Inc.
Ethyl Corporation

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Farris Engineering Corporation
The Fish Engineering Corp.
The Fisher Governor Company
Flint Steel Corporation
Flow Measurement Co.
The Fluor Corporation, Ltd.
Fluor Products Company
The Foxboro Company
France Packing Company

Gardner-Denver Company
The Garlock Packing Company
Gas Equipment Co., Inc.
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The Marley Company, Inc.
Chas. Martin & Company
The Marsh Company
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Massey Machine Div. Curtiss-Wright Corp.
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Plibrico Company
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Power Machinery Co.
Power Specialty Co.
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Southwest Industries, Inc.
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Stockham Valves & Fittings
Superior Mfg. Co.

Taylor Forge & Pipe Works
Taylor Instrument Companies
Tellepsen Petro-Chem Constructors
The Tennant Co.
Termomeccanica Italiana, SpA
Trinity Steel Company, Inc.
Tube Turns Div.—National Cylinder Gas Co.
Tuloma Builders, Inc.
Tyler-Dawson Supply Co.

Union Steam Pump Sales Co.
United Centrifugal Pumps
United Chemical Corp.
Universal Oil Products Co.

Vinson Supply Company
Vulcan Steel Tank Corp.

Walco Engineering & Constr. Co.
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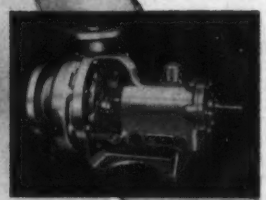
Well Equipment Division of Chiksan Co.
Westcott & Greis, Inc.
Western Chemical Co., of K. C., Mo.
Western Chemical & Supply Co.
Western Supply Company
The Wickes Boiler Co.
Wilson Supply Co.
Wolverine Tube Division
Woobank Machinery Co.
World Petroleum
Worthington Corporation
Wright Chemical Corporation
Wyatt Metal & Boiler Works

John Zink Burner Company

For more data on advertised products, use Readers' Service Cards, last page.

"NOW-WE CAN BE SURE!"

Pump Buyers are saying this about Peerless Process Pumps—



PEERLESS PUMPS

Putting Ideas to Work

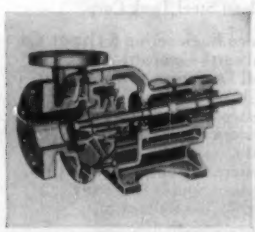
fmc FOOD MACHINERY AND CHEMICAL CORPORATION

Peerless Pump Division

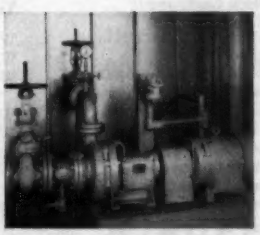
Plants: LOS ANGELES 31, CALIFORNIA and INDIANAPOLIS 8, INDIANA

Offices: New York, Atlanta, St. Louis, Phoenix, San Francisco, Chicago, Fresno, Los Angeles, Plainview and Lubbock, Texas, Albuquerque. Distributors in Principal Cities. Consult your telephone directory.

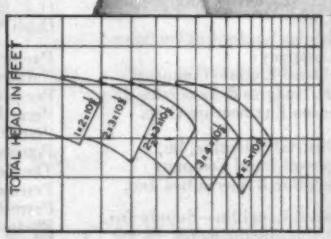
HERE ARE 4 CONVINCING REASONS WHY:



THEY OFFER the type of quality construction that measures up to any standard. Continual checking at every stage of manufacture guarantees the buyer performance he can count on in the field. *The best!*



THEY PROVIDE the performance you expect and pay for, backed by actual operating records of Peerless pumps in installations like yours. Durability, dependability, efficiency—*all proved in service.*



THEY MEET *exactly* every pumping requirement, handle any job in your system that calls for a pump. The *complete* Peerless range offers *all* types of chemical process pumps, in *all* sizes and frames.

AN EXAMPLE of Peerless research is this recently released bulletin on the effects of radial loads in process pumps, "MECHANICAL CONSIDERATION IN PUMP DESIGN." Request Bulletin No. EM-79.

DU PONT *Petroleum Chemicals* NEWS

Number 85 in a Series of Bulletins for the Petroleum Industry

MARCH 1958

ANOTHER DU PONT SERVICE...

New bulletin service provides tips on additives handling

The chief aim of our newest service is to make the use of additives as easy and economical as possible for Du Pont customers.

As a leading supplier of tetraethyl lead and other petroleum additives, the Du Pont Petroleum Chemicals Division employs a staff of engineers who are also additives handling specialists, the "Operations Group." These men have had broad experience in their field. To pass their know-how along to you in the oil industry, we now issue, from time to time, "Additives Handling Bulletins."

THE NEW series of additives handling bulletins will be available to you in this convenient filing folder.

OVER

BASIC RESEARCH IS A NEVER-ENDING PROJECT AT DU PONT

Last year, the Du Pont Company spent approximately $15 million for *basic* research alone—research into unexplored spheres of chemistry.

The expenditure represents nearly 20% of the company's total investment, almost $80 million, in research and development. Last year marked the 30th anniversary of our basic research program, which has yielded new knowledge and eventually contributed to the development of many new Du Pont products. Among the fundamental research projects undertaken by the Du Pont Company back in 1927 was the work on condensation polymers. This work has since borne fruit by forming the scientific basis which led to such products as nylon, "Zytel" nylon resin, "Delrin" acetal resin, "Mylar" polyester film, and "Cronar" polyester film base. The long list of other products stemming from our basic research projects includes neoprene synthetic rubber, weed killers, and polyurethanes.

A pioneer

Du Pont has been one of the industrial pioneers in basic research. Back in 1927, virtually all industrial research was "practical," aiming directly at product discovery and development. Then came, in addition, the quest for more pure scientific knowledge.

Du Pont's belief in the importance of this work has caused basic research to become an immense, never-ending project for the company. Today, approximately 440 Du Pont scientists are engaged in this type of activity and, altogether, 2,170 are working exclusively on research and development projects.

Fundamental combustion research

The Petroleum Chemicals Division participates in this program through such research as our continuing fundamental combustion studies at the Du Pont Petroleum Laboratory. The results are made available to the petroleum industry in published papers.

One of our newer products, Fuel Oil Additive No. 2, is an outgrowth of polymer research conducted in the main Du Pont Experimental Station.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

DUPONT *Petroleum Chemicals* NEWS

CONTINUED **Additives Handling**

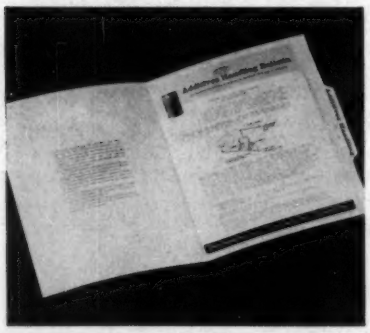
The first of these has recently come off the press. It deals with the use of duplex pumps (instead of the simplex type) for keeping additives free-flowing in cold weather.

By using this type of pump, installed with the additives drum in a heated building or cabinet, the additive, with diluent, can be piped for a considerable distance outdoors in cold weather. Thus the necessity of either heating or insulating pipes is avoided.

A diagram shows clearly how the pump can be set up in a typical refinery treating system. Information on installation, applications, variations, advantages, and costs is included in the bulletin.

Future subjects

Other bulletins in the series which will be published shortly will discuss such subjects as methods of pumping, heating, dispensing, storage.



EACH BULLETIN WILL CONTAIN detailed data and diagrams on the additives handling aid featured.

There is no definite publication schedule. We plan to issue them as often as helpful ideas are developed. If you would like to receive copies, just get in touch with one of our representatives at any of the sales offices listed at the right.

See the "Du Pont Show of the Month" on CBS

HEADS UP EASTERN REGION

EARL G. BENNETT is Eastern Regional Manager for the Du Pont Petroleum Chemicals Division, with headquarters in New York City. Prior to this assignment, he was Central Regional Manager in Chicago.

Mr. Bennett has been with the Du Pont Company since 1931. His first job was in the Grasselli Chemicals Department. In 1934 he was transferred to a sales position in the Organic Chemicals Department.

In 1939 he went to Chicago in charge of sales in the Western area for the organization now known as the Petroleum Chemicals Division. He returned to Wilmington in 1943 as a member of our Petroleum Laboratory staff. He was appointed Central Regional Manager in 1947.

Mr. Bennett was graduated from Clarkson College of Technology with a B.S. degree in chemical engineering. He is a member of the American Chemical Society, the Society of Automotive Engineers, and the American Petroleum Institute.

When he recently took over the managership for the Eastern Region, he succeeded Mr. Alfred R. Mullis, who became assistant director of sales in Du Pont's home office, Wilmington. And Mr. Bennett was succeeded in the Central region managership by Mr. Donald W. Frison, formerly manager for Mid-Continent region in Tulsa.

To Reduce Treating Costs...

You can sweeten AND stabilize, both with a single additive

You can take both of these important steps in a single, inexpensive operation with one additive—Du Pont Antioxidant No. 22 (AO-22).

YOU CAN obtain copies of these booklets on antioxidant sweetening from any of our sales offices listed at right.

Antioxidant sweetening equipment is less expensive than other types. And no sulfur or copper is required – so there is no chance of contamination from these elements. Also, there is no loss of gasoline or octane number.

SALES OFFICES

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Houston 2—705 Bank of Commerce Bldg. . . . . CApitol 5-1151
Los Angeles 17—612 So. Flower St. . MAdison 5-1691
New York 20—1270 Ave. of the Americas . . . . . COlumbus 5-2342
Philadelphia 2—3 Penn Center Plaza . LOcust 8-3531
Pittsburgh 22—1 Gateway Center . . . ATlantic 1-2933
San Francisco 4—111 Sutter St. . . . . EXbrook 2-6230
Seattle 3—4003 Aurora Ave. . . . . MElrose 6977
Tulsa 1—1811 So. Baltimore Ave. . . . . LUther 5-5578
In Canada—Du Pont Company of Canada (1956) Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12**—Ontario . . . . . HUdson 1-6461
In Other Countries—Organic Chemicals Department, Export Division, 7447 Nemours Bldg., Wilmington 98, Del., OLympia 4-5121, Ext. 2962.

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living ... *through Chemistry*

Du Pont Tetraethyl Lead and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-6293

Printed in U. S. A.

ACCO
for Better
Values

R-P&C VALVES

THE COMPLETE LINE
—DESIGNED FOR DEPENDABILITY

R-P&C "Sure-Tight" LUBROTITE GATE VALVES

—THE MULTI-SERVICE VALVES LUBRICATED THROUGH THE SEAT RINGS

Lubrotite Gate Valves—created and patented by R-P&C—are built to provide absolute tightness and long, trouble-free service in handling all fluids for which iron and cast steel valves are serviceable.

By the unique Lubrotite system, in which each seat ring is served by a Lubrotite gun, a lubricant seal is forced through to the valve's seating surface. This lubricant prevents leakage, retards corrosion, prevents sticking, reduces wear on seating surfaces and makes for easier operation. Net result: reduced operating, maintenance and over-all valve costs!

Available in cast steel and iron types. A wide variety of lubricant seals, each suitable for numerous services, can be furnished.

Lubrotite Gate Valves are giving highly successful service in handling—

Gasoline...Oil...Benzol...HF Alkylation...
other Petroleum Derivatives —
Natural and Artificial Gas...Air...
Helium Gas...Coke and Gas...Water —
Vacuum Service (evaporation, etc.)...
Feed Water Lines and Steam Plants —
Mine and Acid River Waters...
Certain Chemicals...Other Services

Lubrotite Gate Valves form a part of the complete R-P&C line, which includes gate, globe, angle and check valves in all standard materials; all in a wide range of sizes, styles and pressure classes. Order through nearby R-P&C Distributor. Write our Reading office for catalog.

FREE WALL CHART
"How to Protect Your Valves"
Installation pointers, operating tips, clues to longer valve life. They are all on this 22" x 17" wall chart. Write for your free copy.

R-P&C VALVE DIVISION
AMERICAN CHAIN & CABLE

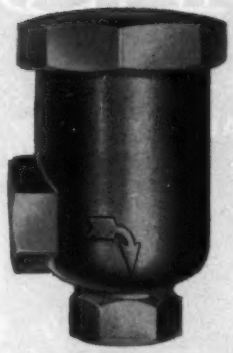
Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

ACCO

need steam traps?

name the way you want them!

TYPE A



TYPE D

TYPE C

Nicholson can supply your steam traps, exactly as you want them . . . for any service, any condition. Name the size, material, pressure, capacity you need. Types A, D, C are the ones you'll most likely use. Make your selection.

Sizes: A—from ¼" to 1". D—from ¼" to ¾". C—from ½" to 2".

Materials: Cast Iron, Cast Steel and Bronze.

Pressures: A and D—Vacuum to 200 lbs. C—Vacuum to 300 lbs.

Capacities: From two to six times greater orifice area and capacity than other traps of comparable size.

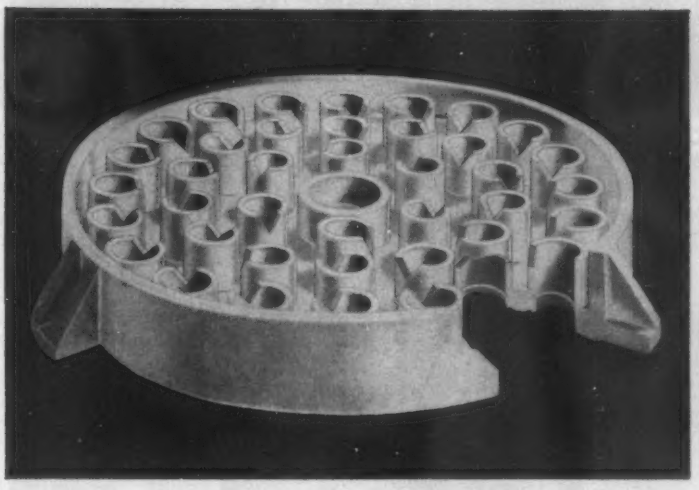
Why wonder about your steam traps . . . when you can get Nicholsons exactly as you need them for your own applications. Nicholson traps are simple in design, have only one moving part . . . a valve that discharges condensate and prevents steam loss.

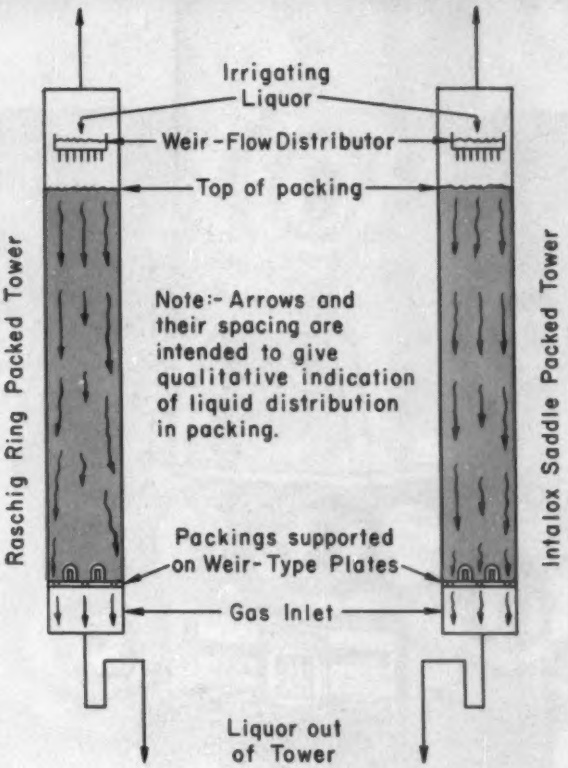
You get faster warmup, with high air-venting capacity. You eliminate costly leakage, with a powerful shut-tight valve action. You get a trap that's service-tested, when you specify Nicholson. You can try one . . . without obligation! W. H. Nicholson and Company, 12 Oregon St., Wilkes-Barre, Pa. Sales and engineering offices in 98 principal cities.

NICHOLSON

of Wilkes-Barre

How to achieve better liquid distribution in PACKED COLUMNS




Irrigating Liquor
Weir-Flow Distributor
Top of packing
Raschig Ring Packed Tower
Note:- Arrows and their spacing are intended to give qualitative indication of liquid distribution in packing.
Intalox Saddle Packed Tower
Packings supported on Weir-Type Plates
Gas Inlet
Liquor out of Tower

Full utilization of packing surface area in a column can only be realized if liquid distribution (both initially and throughout the bed) is such as to provide maximum *wetted* surface area.

The unique shape of the Intalox Saddle packing permits a thoroughly randomized arrangement of the packed bed, with a virtual absence of pattern packing. Thus, good initial distribution remains intact for greater packed heights than for columns of other packings, notably rings.

Now, U. S. Stoneware makes available two new types of tower distributors, each designed to take full advantage of the better internal distribution of Intalox Saddles. The "Multi-Level" is designed for low liquid rates; the "Weir-Flow"* for medium-to-high liquid rates. Both distributors assure infinitely better initial liquid distribution than the conventional types of distributors heretofore available. While designed for use with Intalox Saddles, they will improve the distribution characteristics of any packed bed.

* *Made in chemical ceramics, carbon steel, or stainless.*

131-F

Full details in this NEW Bulletin

Bulletin TA-30 describes these new distributors. Gives data on packing support plates, how to install; when to re-distribute, and other data helpful to designers of packed columns. Free on request. Address Dept. PR 358, U. S. Stoneware, Akron 9, O.

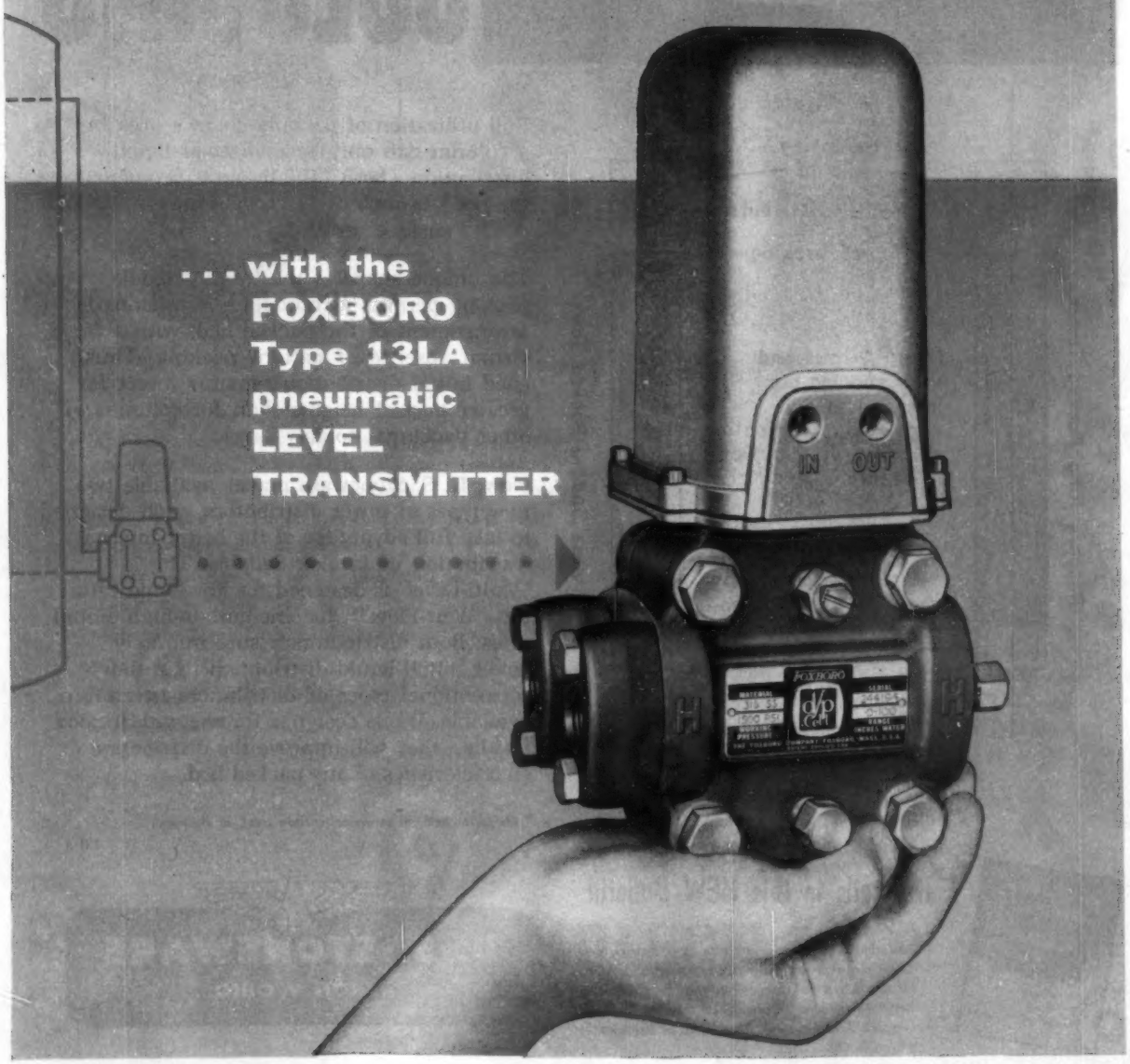
U. S. STONEWARE
AKRON 9, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

GREATER SIMPLICITY

FOR LIQUID LEVEL

. . . with the
FOXBORO
Type 13LA
pneumatic
LEVEL
TRANSMITTER



MEASUREMENT !

Easy Low-Cost Installation on any closed or open tank. Only two small pressure taps required. Nothing inside tank!

Fully-Adjustable Ranges . . . 0-20" to 0-250" and 0-200" to 0-800" H_2O.

Complete Adjustment for elimination of outside leg effect gives forward-reading signal to any standard receiver!

Highest Sustained Accuracy . . . Instant, precise response to level changes even under extreme operating conditions.

Rugged and Corrosion-Resistant . . . Level-sensing element is Type 316 stainless steel, silicone-filled "capsule" diaphragm applicable on static pressures up to 1500 lbs.

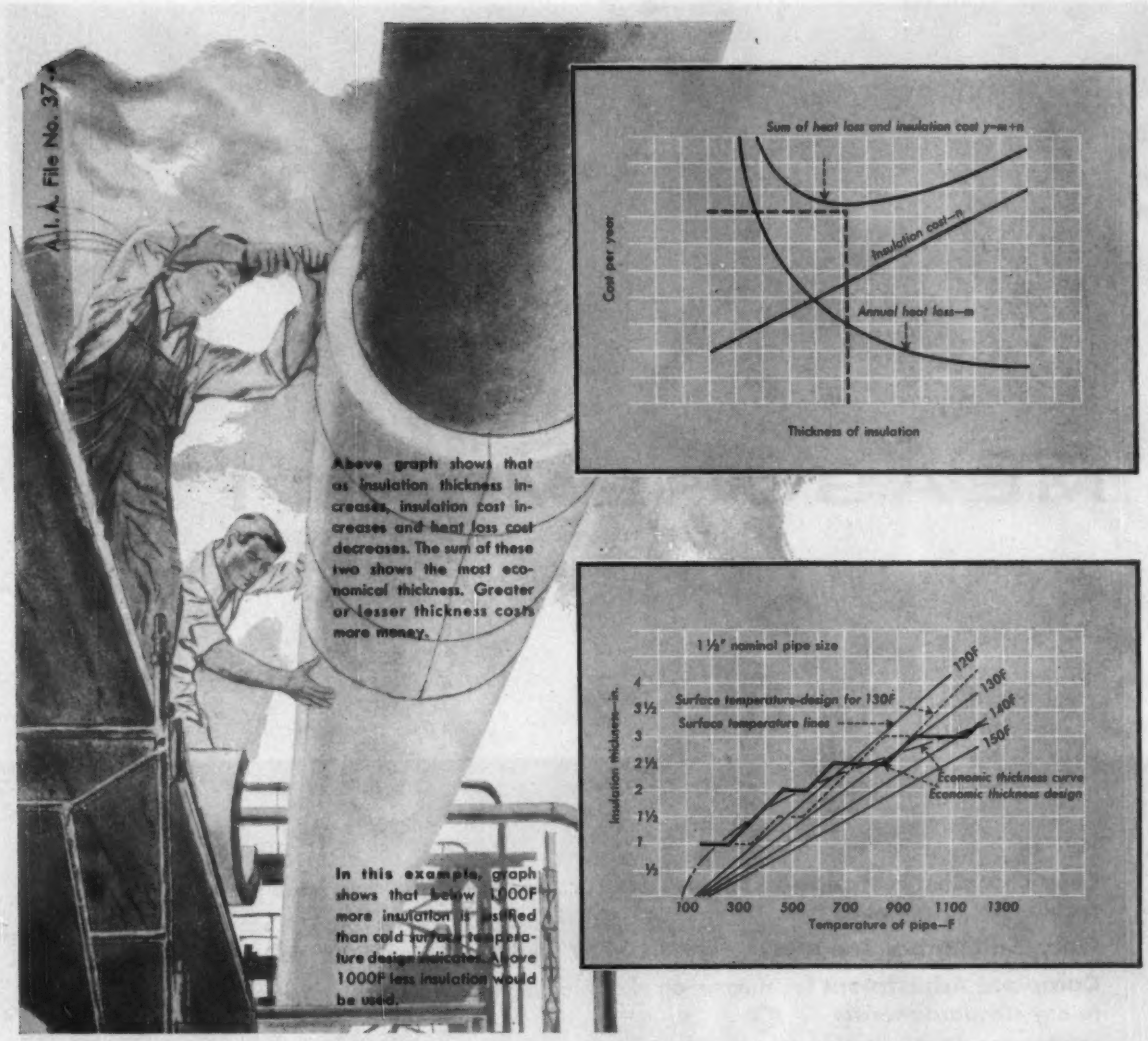
There's nothing simpler for accurately measuring liquid level than the Foxboro Type 13LA d/p Cell* Liquid Level Transmitter! No floats, knife edges, stuffing boxes, or complicated hook-ups. A simple, direct piping job connects it to the tank . . . operates in any position, even upside down. The Transmitter precisely measures difference in head caused by level change . . . sends 3-15 psi air signal over single air line to indicator, recorder, or controller. It's easily traced when required, up to 250°F., to maintain fluidity of liquid.

The 13LA d/p Cell Transmitter is low in initial cost, requires practically no maintenance. In addition, it is easily converted in field for the measurement of fluid flow. It's the ideal instrument for heavy industrial applications . . . indoors or out. For complete details, ask your nearest Foxboro Field Engineer, or write for new Bulletin 13-22A to The Foxboro Company, 743 Neponset Ave., Foxboro, Mass., U.S.A.

*Reg. U. S. Pat. Off.

FOXBORO
REG. U. S. PAT. OFF.

LIQUID LEVEL TRANSMITTER



"COLD SURFACE" CRITERION WASTES MONEY!

How J-M engineers determine economic insulation thickness

to give you more for your insulation dollar

OVER-ALL cost of the operation should always be the determining factor in selecting insulation thickness. Yet, millions of dollars have been wasted because of rigid adherence to the cold surface temperature method. When Johns-Manville insulation is applied, J-M engineers carefully determine which thickness will provide the greatest operational savings. And this "economic thickness" is usually more (or less) than the cold surface method indicates.

Here's how it works. The annual cost of the heat loss through the insulation is plotted for various thicknesses. Also plotted is the annual cost of insulation. A third curve is then drawn as the sum of heat loss and insulation cost. The economical thickness is found where this third curve reaches its lowest point.

To arrive at the above figures in a given instance requires the following: 1. Cost of heat production per million Btu; 2. Rate of heat loss through insulation in Btu per unit area per hr; 3. Annual hours of operation; 4. Applied cost of insulation per unit area; 5. Rate of amortization and required return on the insulation investment cost. Items 2 and 4 are available from the insulation manufacturer; others are normally supplied by the plant engineer.

For more complete information, call or write Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario. Ask for reprint of technical article "Select Economic Insulation Thickness."

JOHNS-MANVILLE

JOHNS-MANVILLE PRODUCTS

For more data on advertised products, use Readers' Service Cards, last page.

POWELL

world's largest family of valves

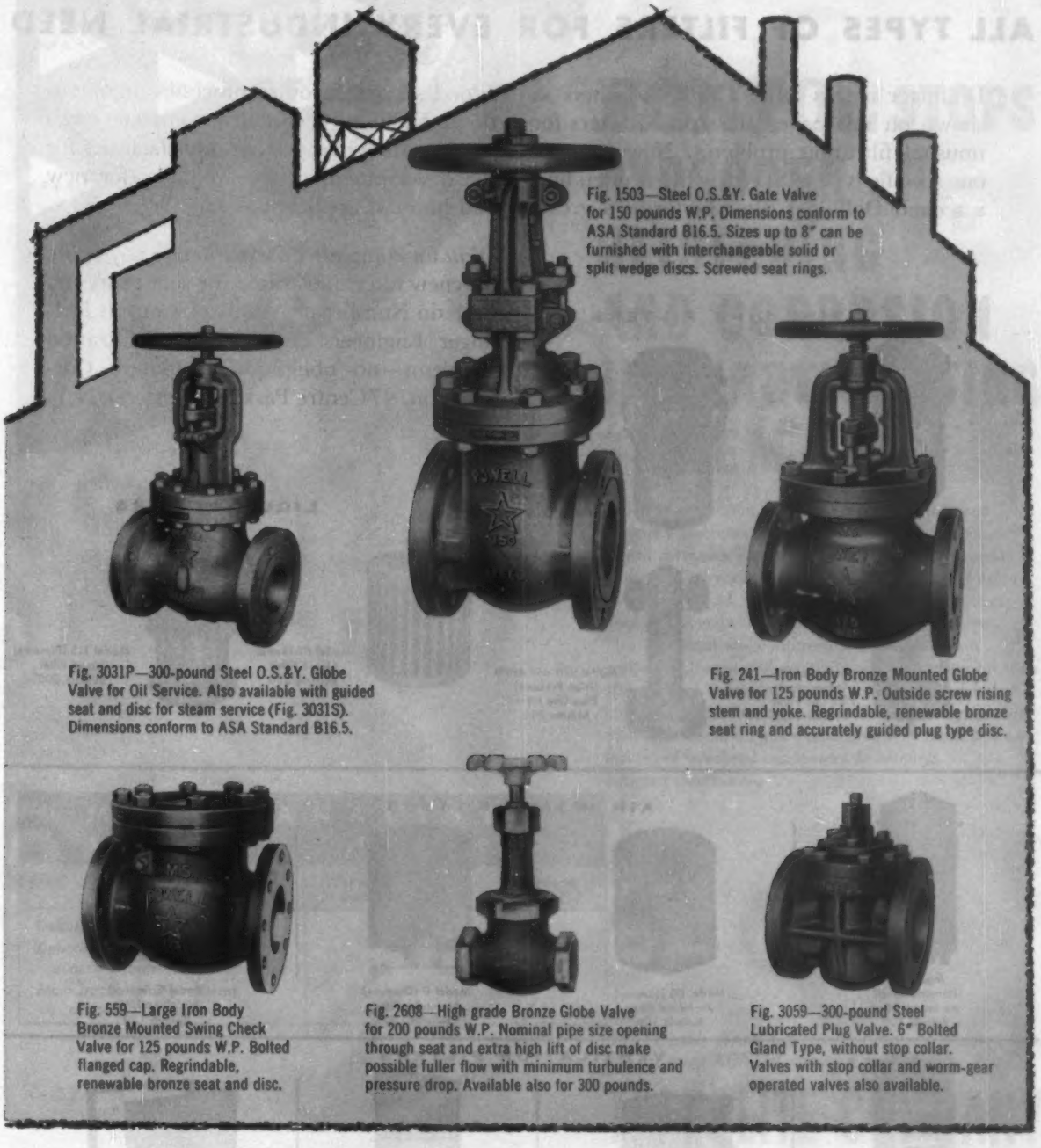


Fig. 1503—Steel O.S.&Y. Gate Valve for 150 pounds W.P. Dimensions conform to ASA Standard B16.5. Sizes up to 8" can be furnished with interchangeable solid or split wedge discs. Screwed seat rings.

Fig. 3031P—300-pound Steel O.S.&Y. Globe Valve for Oil Service. Also available with guided seat and disc for steam service (Fig. 3031S). Dimensions conform to ASA Standard B16.5.

Fig. 241—Iron Body Bronze Mounted Globe Valve for 125 pounds W.P. Outside screw rising stem and yoke. Regrindable, renewable bronze seat ring and accurately guided plug type disc.

Fig. 559—Large Iron Body Bronze Mounted Swing Check Valve for 125 pounds W.P. Bolted flanged cap. Regrindable, renewable bronze seat and disc.

Fig. 2608—High grade Bronze Globe Valve for 200 pounds W.P. Nominal pipe size opening through seat and extra high lift of disc make possible fuller flow with minimum turbulence and pressure drop. Available also for 300 pounds.

Fig. 3059—300-pound Steel Lubricated Plug Valve. 6" Bolted Gland Type, without stop collar. Valves with stop collar and worm-gear operated valves also available.

For every flow control problem Powell offers more kinds or types, available in the largest variety of metals and alloys to handle every flow control requirement. Powell distributors are located in all principal cities and maintain inventories to fill almost any need. For special engineering problems, write direct to:

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

For more data on advertised products, use Readers' Service Cards, last page.

PROTECTOMOTOR
STAYNEW
FILTERS

DOLLINGER

ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

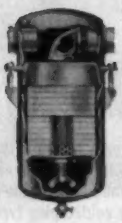
Dollinger makes ALL TYPES of filters as shown on this page, plus special filters for unusual filtration problems. New users of one specific type of Staynew filters often find a second Dollinger filter performs a great, added service in other processes or operations. Dollinger maintains complete engineering, design and laboratory facilities for the development of special filters for new and unusual applications.

Write for complete information on any of the Staynew filters illustrated. Be sure to specify Bulletin Number or Numbers. Consult Dollinger Engineers on any special filtration problems—no obligation. Dollinger Corporation, 47 Centre Park, Rochester 3, N.Y.

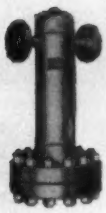
PIPE LINE FILTERS

Model CPH
Pipe Line Filter
Bulletin 200

Model CVH (Vacuum)
Pipe Line Filter
Bulletin 200



Model AAPHS
(Absorption)
Pipe Line Filter
Bulletin 200



Model HPH and AHPH
(High Pressure)
Pipe Line Filter
Bulletin 200

LIQUID FILTERS

Model HE (Sump)
Liquid Filter
Bulletin 330

Model ELS (Pressure)
Liquid Filter
Bulletin 300

AIR INTAKE FILTERS

Model IDR
(Ground Level)
Air Intake Filter
Bulletin 100

Model DS (Silencer)
Air Intake Filter
Bulletin 100

Model D (Outdoor)
Air Intake Filter
Bulletin 100

Model C (Indoor)
Air Intake Filter
Bulletin 100

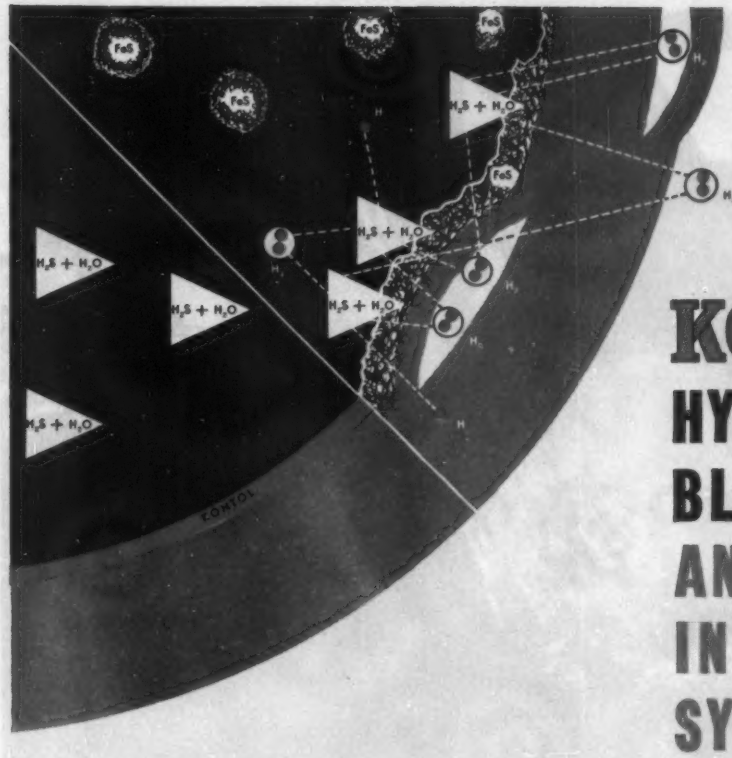
VENTILATION FILTERS

Electro-Staynew
Mist Collector
Bulletin 420

Electro-Staynew
Precipitator
Bulletin 400

Automatic
Ventilation Filter
Bulletin 500

Dry and
Viscous Panel
Ventilation Filters
Bulletin 600 and 700



KONTOL STOPS HYDROGEN BLISTERING AND CORROSION IN FRACTIONATING SYSTEM

Before protection with Kontol, a mid-continent refinery's fractionating system was plagued by widespread corrosion and hydrogen blistering. Hydrogen probe activity registered a 25 psi pressure build-up in an 8-hour period. Kontol was injected into the overhead of the main fractionator at the rate of 9 ppm. This treatment was continued over an 18 month period. Hydrogen probe activity was practically nil soon after Kontol treatment was started. Visual inspection indicated no further appreciable damage to equipment, with all condensers and exchangers very clean and no leaking of overhead condensers developing between shutdowns.

METAL ANALYSES since KONTOL treatment

AREA	% reduction in iron content	% reduction in copper loss
Debutanizer feed drum water	93	70
Debutanizer overhead accumulator water	85	46
Main fractionator overhead accumulator water	90	67

WRITE today for the full report on this and other refineries who are using KONTOL corrosion preventives.

TRETOLITE COMPANY

DIVISIONS OF PETROLITE CORPORATION

369 Marshall Avenue, Saint Louis 19, Missouri
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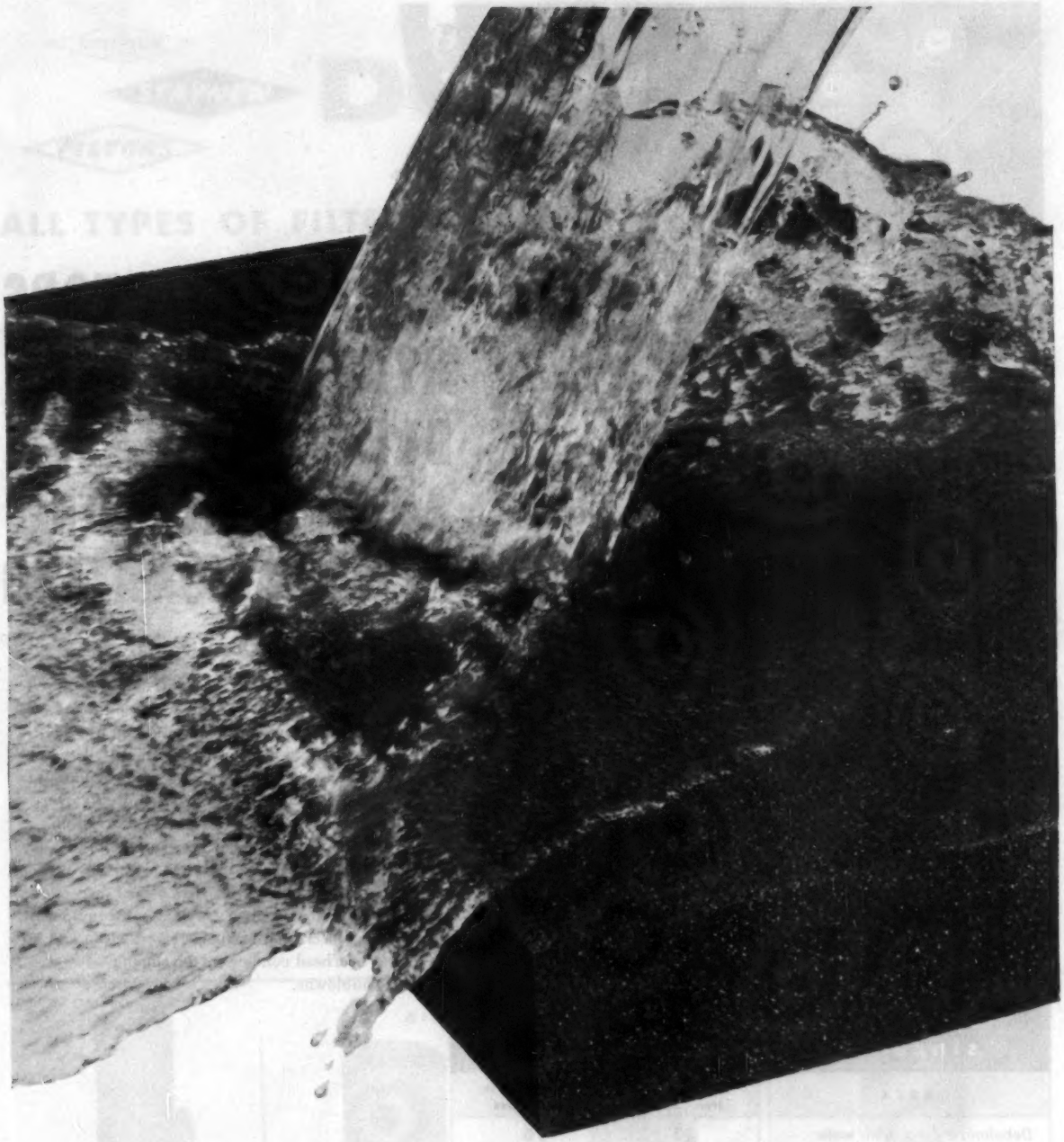
Chemicals and Services for the Petroleum Industry

DESALTING • CORROSION INHIBITING
DEMULSIFICATION • SCALE PREVENTION • WATER DE-OILING
METAL DEACTIVATION • ADDITIVES

KR-58-1

For more data on advertised products, use Readers' Service Cards, last page.



. . . always an insulation investment; never an insulating expense

FOAMGLAS® IS MOISTURE-PROOF

Insulation that absorbs moisture soon stops insulating. That happens to most insulations, in time. It never happens to FOAMGLAS . . . because FOAMGLAS is moisture-proof. Its sealed glass cells can never absorb water or vapor. It always maintains its full, original insulating value. There's more to this insulation investment story. FOAMGLAS is incombustible . . . dimensionally stable . . . unusually strong . . . acid-proof . . . vermin-proof . . . easy, economical to handle and install. Find out how to make this long-term investment in your own insulated buildings and equipment. Write for our latest catalog.

PITTSBURGH CORNING CORPORATION

Dept. Z-38, One Gateway Center, Pittsburgh 22, Pa. • In Canada: 57 Bloor Street West, Toronto, Ontario

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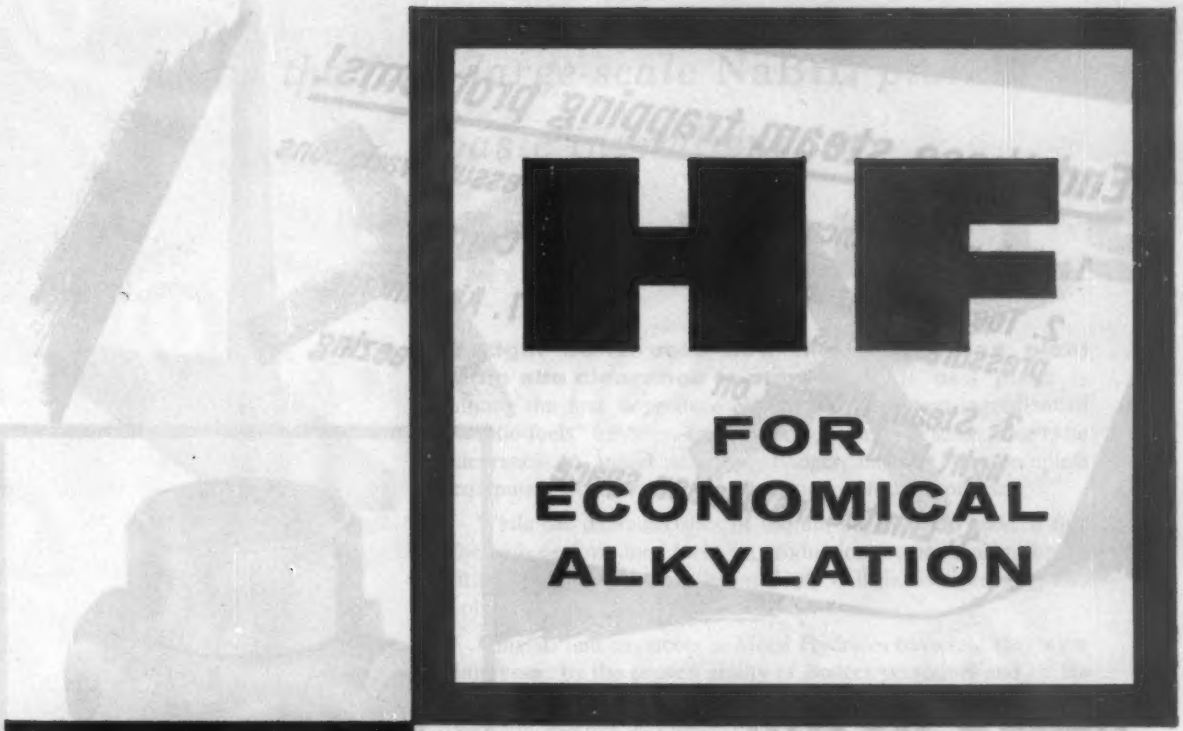


HF
FOR ECONOMICAL ALKYLATION

Pennsalt for HF safety

HF alkylation pays off in lower operating cost, elimination of spent acid problems, and simpler, less expensive cooling equipment.

You can get the benefits of HF now. Pennsalt is ready to give you expert technical assistance in handling and storing HF safely in your refinery. We can help you set up employee training programs and, from our long experience in working with HF, we can advise you on the types of materials, piping, valves, and other equipment that are best for HF service. We have the answers to HF problems because . . .

Pennsalt has been a pioneer and leader in fluoro-chemistry for over 40 years . . . *specializes* in hydrofluoric acid production, shipping and handling. Pennsalt HF is made in modern plants under careful quality control, to assure you purity that meets or exceeds alkylation process needs. It is available in cylinders and tank cars of convenient sizes.

Get the *facts* on HF. Call or write Pennsalt today.

See our Catalog in CMC

INDUSTRIAL DIVISION
PENNSALT CHEMICALS CORPORATION
3 Penn Center, Philadelphia 2, Pa.
Regional Offices:
Chicago • Detroit • New York • Philadelphia • Pittsburgh • St. Louis
District Offices: Appleton • Cincinnati • Atlanta
Representatives: Airco Company International, New York
Pennsalt Chemicals of Canada Ltd., Oakville, Ontario

Pennsalt Chemicals
ESTABLISHED 1850

In the West, Pennsalt inorganic chemicals are available through Pennsalt of Washington Division, with plants at Tacoma, Washington and Portland, Oregon.

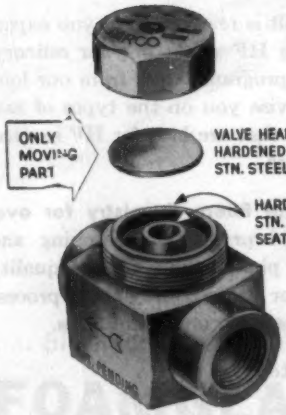
For more data on advertised products, use Readers' Service Cards, last page.

End these steam trapping problems!

1. High maintenance cost
2. Too many sizes and pressure ratings
3. Steam blowing on light load
4. Limited installation space
5. Pressure variations
6. Corrosion
7. Air binding
8. Freezing

ACTUAL SIZE

HERE'S HOW...
with the versatile Sarco TD Thermodynamic Steam Trap



ONLY 3 PARTS
SIMPLE—TROUBLE-FREE

All parts machined from stainless steel bar stock. Only moving part—a solid hardened stainless steel disc—practically wear-proof.

No mechanism—the kinetic energy of steam closes the valve. No narrow channels to choke. No gaskets to leak.

1. **Practically eliminates maintenance**—as shown, left, the TD has only 3 simple, rugged parts—all stainless steel. No mechanism . . . to wear or malfunction. Highly resistant to superheat, water-hammer, corrosive condensate.
2. **One trap for all pressures**—10 to 600 psi—for light or heavy loads. Self-adjusting—each size Sarco TD uses same large capacity seat for all pressures—without change or adjustment.
3. **Won't blow steam on light loads**—no prime to lose—no adjustments.
4. **Small as a tee fitting**—½" size, for example, only 2¾" long, 1¼" wide, 2⅛" high.
5. **Operates perfectly when pressure fluctuates**—absolutely no effect from 600 to 10 psi! No water seal to evaporate. No adjustments.
6. **Unaffected by corrosive condensate**—made of stainless steel throughout.
7. **No air-binding**—discharges at steam temperature and vents air and air-steam mixtures at start-up and during operation.
8. **Freeze-proof**—self-draining when installed with outlet down.

60-DAY TRIAL CONVINCES

We will gladly send you a Sarco TD steam trap and strainer for 60-day trial. No cost or obligation. You buy *only* if completely satisfied. Advise size—⅜, ½, ¾ or 1"—and application. Sarco Company, Inc., 635 Madison Avenue, New York 22, N. Y.

2217-B

SARCO Thermo-Dynamic TRADE MARK **STEAM TRAP**

THE MODERN STEAM TRAP—THAT CAN DO MORE THINGS BETTER!

from the first large-scale $NaBH_4$ *plant comes a basic ingredient for*

ZIP FUELS

Badger constructs new Metal Hydrides plant from site clearance to start-up. This new plant is among the first to produce $NaBH_4$, an important ingredient of "exotic fuels" for trans-sonic devices, on a large scale. From site clearance to initial start-up, Badger handled the complete equipment engineering and construction for the project.

While the characteristics of sodium borohydride make it fine for high performance fuels, its production creates real problems in equipment and plant design. How well did Badger meet and solve these problems?

Officials and engineers at Metal Hydrides have said they were impressed by the proven ability of Badger personnel and by the intelligent approach that was brought to MHI's problem. In addition, Badger was complimented for its willingness to undertake the project on a "crash" schedule. Metal Hydrides' judgment proved sound when Badger delivered the plant on schedule in spite of delays due to the steel strike.

Each year more and more leading firms with unusual and pioneering engineering projects choose Badger. The ability and experience that lead so many to the same choice can pay off on your projects, too. Why not inquire?

The Badger Key Man

FROM INITIAL NEGOTIATIONS TO "ON STREAM" YOU DEAL WITH A BADGER PRINCIPAL. *Badger Engineering Projects are group efforts headed by a Key Man. More than just a sales engineer, he is always a Badger principal — always the Key Man in the execution of the project.*

By channeling project liaison, coordination and administration through a widely experienced company principal, you find many policy level decisions can be made on the spot. Investigate what Key Man Policy can mean to the projects you are planning.

BADGER

MANUFACTURING COMPANY

ENGINEERS ◇ CONTRACTORS ◇ DESIGNERS ◇ MANUFACTURERS

230 Bent St., Cambridge, Mass.

New York, N.Y. • Houston, Texas

IN EUROPE: Badger-Comprimo N.V., The Hague

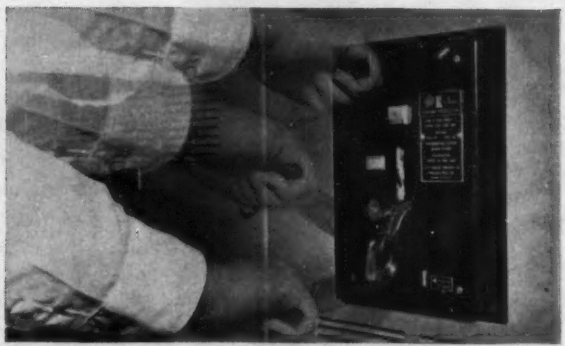
Badger-Comprimo S.A., Antwerp

Aerial view of Metal Hydrides' new Sodium Borohydride Plant at Danvers, Massachusetts, as it looked while under construction. The plant process involved the preparation of sodium borohydride using sodium and boric acid as raw materials.

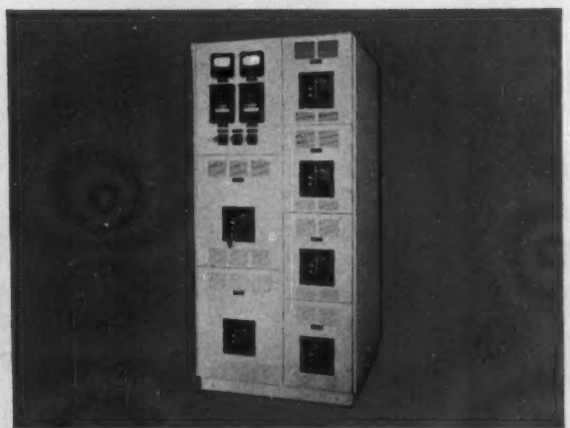
I-T-E makes sweeping design advances in new low voltage power circuit breakers, switchgear

I-T-E's new K-Line offers better performance, greatly simplified operation and servicing, and standardization in construction and assembly

Now we offer a complete new design of equipment for the switching, control and protection of motor, generator, transformer and feeder circuits, as well as other large electrically powered facilities—the most sweeping design advance in 13 years. Among the major innovations in the new design are the following.



First quick-make manually charged stored energy closing mechanism. First 90% of pulldown handle travel charges spring mechanism, last 10% releases stored energy, automatically closes contacts. No teasing of contacts is possible.

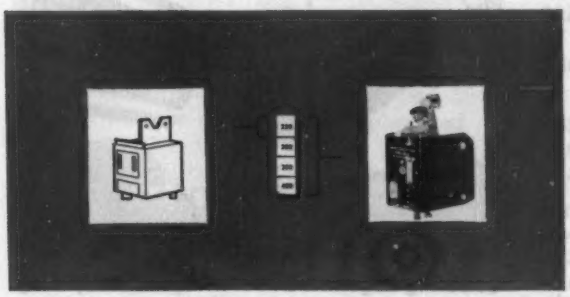


4-high stacking of 600 amp frame size circuit breakers in 90-in.-high enclosures. The new circuit breakers are as much as one-third smaller and 55% lighter than comparable units. The new switchgear is the smallest ever designed.

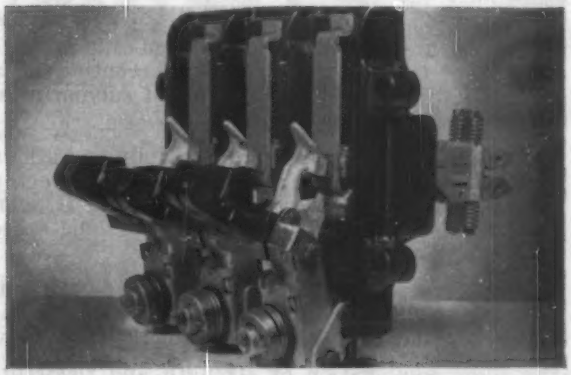
First closed-door drawout of circuit breakers. This permits racking of circuit breaker into connected, test and disconnected positions without opening the door of the circuit breaker compartment. Drawout arrangement keeps circuit breakers clean, aisles uncluttered, promotes personnel safety. Breaker must be opened before shutter can be lifted to insert drawout racking crank. Breaker cannot be closed while shutter is lifted.

Greatly increased accessibility to component parts for operation and servicing. For example, trips on electrically and manually operated breakers are out in the open and can be easily adjusted. Trips also can be changed quickly. One-piece molding holds trip units, which are changed from the rear and in a fraction of the time formerly required.

Stored energy electrical closure that materially cuts control circuit requirements. The motor-driven stored energy system requires only 10 amp from a simple power source, compared to as much as 160 by comparable solenoids. Quick-make manual closure operates on same principle. First 90% of pull-down handle travel charges a spring mechanism. Last 10% releases the stored energy and closes the contacts. No teasing.



Expanded trip flexibility meets last-minute load changes in many instances with the existing trip unit.



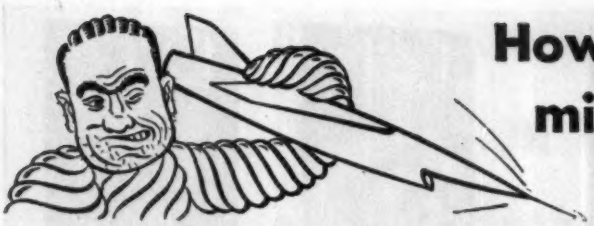
Subassembly circuit breaker construction permits easier, faster replacement of parts. Six major subassemblies replace 130 separate parts in previous models. A part replacement formerly requiring an all-day overhaul of the circuit breaker may mean only removing and replacing a unit subassembly—a matter of minutes.

Bulletin 6004C tells the complete story of this advanced design switchgear. Ask your local I-T-E representative for a copy today. Or write I-T-E CIRCUIT BREAKER COMPANY, Switchgear Division, 19th & Hamilton Sts., Philadelphia 30, Pa.

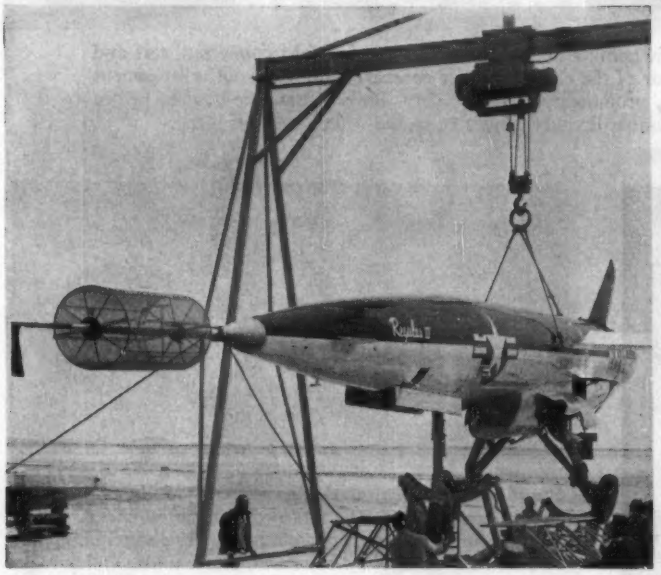
I-T-E CIRCUIT BREAKER COMPANY

19TH AND HAMILTON STREETS, PHILADELPHIA 30, PENNSYLVANIA

For more data on advertised products, use Readers' Service Cards, last page.



How Tuffy Slings move mighty Regulus Missiles



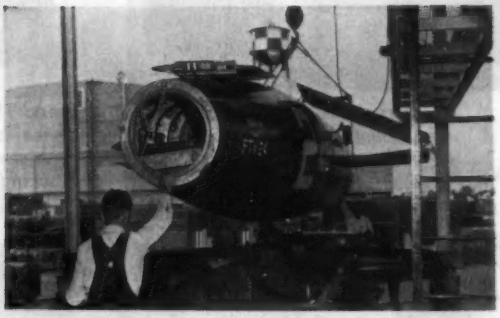
Regulus II gets a lift with Tuffy Slings. This long-range supersonic jet-powered missile is designed for launching from submarines, aircraft carriers, cruisers and shore bases. Test and training versions are equipped with landing gear so they may be recovered after each flight saving taxpayers millions of dollars.

America's intercontinental ballistic missile is still in the future, but the U. S. Navy has intercontinental assault capability today in the combination of submarine and the Regulus I and II guided missiles.

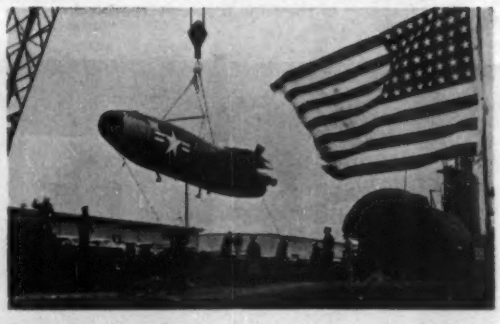
The Chance Vought Regulus I is a fully operational missile that can deliver an atomic warhead more than 500 miles, anywhere in the world. The Regulus II, soon to be operational, has already flown at supersonic speeds and altitudes of more than 50,000 feet.

As the pictures here show, Tuffy Slings are entrusted with the handling of these mighty missiles. Tuffy Slings are used all along the line of production and delivery.

The same combination of strength and flexibility that made Tuffy Slings the choice for this momentous job is yours in Tuffy Slings for every sling use. You get the same machine-braided fabric that resists kinking and from which kinks that do occur are easily removed without material damage. You get the same Tuffy pressed-on ferrule that gives the eye-splice 100% the strength of the fabric. For longer sling life, greater efficiency and safety, get in touch with your Tuffy distributor.



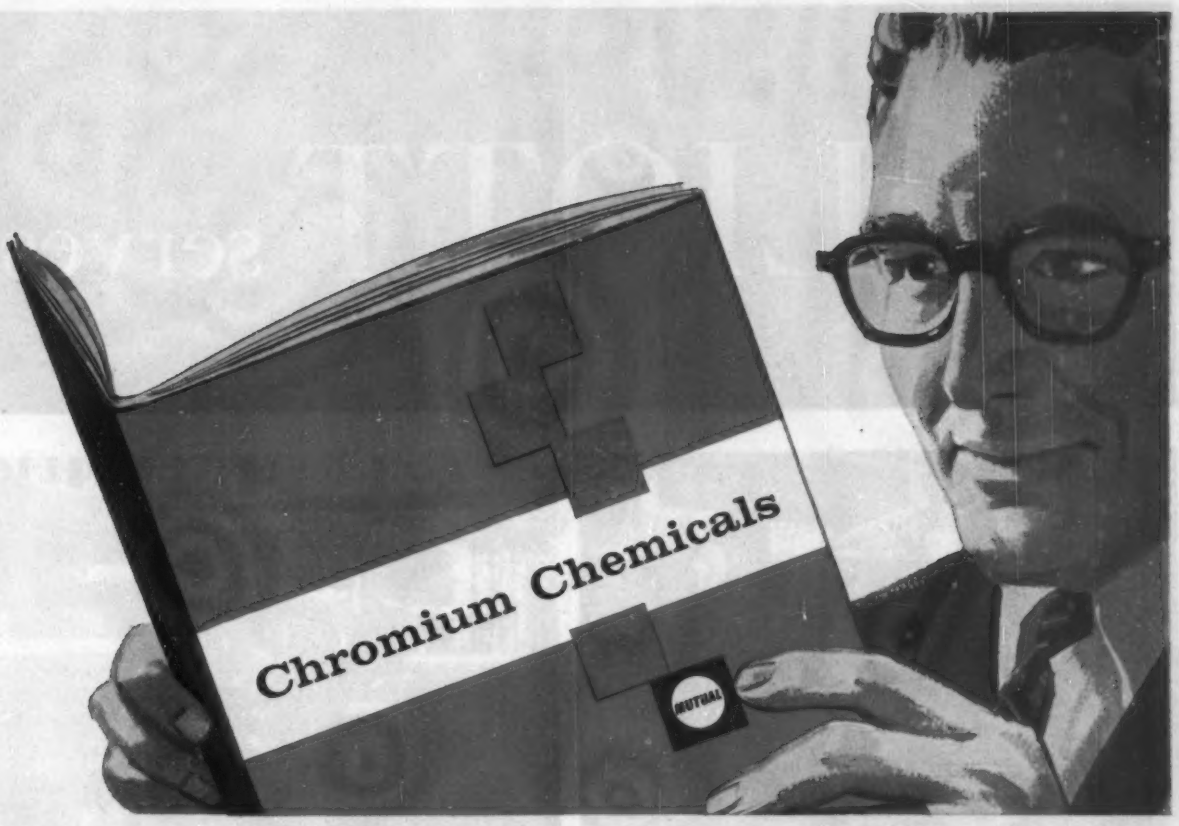
Tuffy helps "can" a missile: Regulus I is shown here being loaded into shipping can with Tuffy Slings. The weight of the missile is classified, but we can say that the weight of the shipping can lid, shown in lower picture, is 3,500 lbs.



Lowering Regulus I onto a submarine, Tuffy Slings are again part of the picture. The fact that such a valuable and vital weapon is entrusted to Tuffy Slings is one of the finest testimonials to Tuffy quality, dependability and safety.

Write today for your copy of
FREE TUFFY SLING HANDBOOK
Full sling data and specifications plus complete rigger's handbook.

union Wire Rope corporation
SUBSIDIARY ARMCO STEEL CORPORATION
2284 Manchester Ave. **Kansas City 26, Missouri**
Specialists in high carbon wire, wire rope, braided wire fabric, stress relieved wire and strand.



the right place to look for

CHROMIUM CHEMICALS

Call Mutual for prompt delivery of chromium chemicals — in the grade and package you need

Whatever your application may be, Mutual can supply you with chromium chemicals which are the quality standard of the industry.

What's more, you're always assured of a dependable supply, on-time delivery and expert assistance from Mutual's technical service staff. Send for the bulletin shown above. It contains detailed information on Mutual chromium chemicals.

Pounds net	Fiber Drums 100	200	264	400	Steel Drums 100	400	Bags (Paper) 75	(Burlap) 100	100
Sodium Chromate									
Anhydrous	X	X		X	X				
Tetrahydrate					X			X	
CP	X			X					
Sodium Bichromate									
Technical*				X	X			X	X
CP					X	X			
Potassium Bichromate									
Technical									
Granular				X	X			X	X
Powdered				X	X				
CP	X			X					
Potassium Chromate									
Technical	X			X					
CP	X			X					
Ammonium Bichromate									
Technical	X			X					
CP	X			X					
Chromic Acid					X	X			
Korean "M" & "X"			X				X		

** Also shipped as 69% solution in 8000-gallon tank cars.*

Mutual Chromium Chemicals

MUTUAL

Sodium Bichromate · **Potassium Bichromate**
Sodium Chromate · **Potassium Chromate**
Chromic Acid · **Ammonium Bichromate**
Korean (one-bath chrome tan)

Mutual Chromium Chemicals are available through dealers and SOLVAY branch offices located in major centers from coast to coast.

MUTUAL CHROMIUM CHEMICALS
SOLVAY PROCESS DIVISION
Allied Chemical & Dye Corporation
Dept. 23, 61 Broadway, New York 6, N. Y.

Please send your Bulletin 52, "Chromium Chemicals," by return mail.

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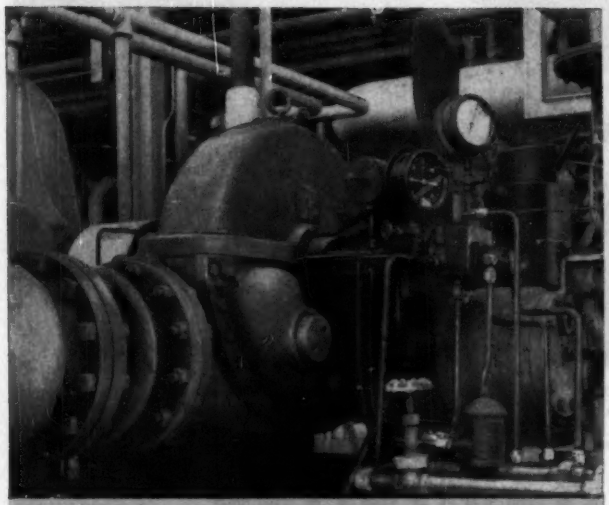
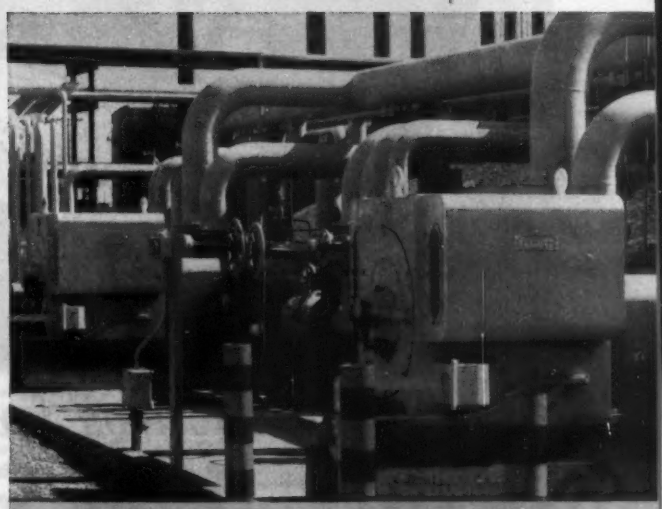
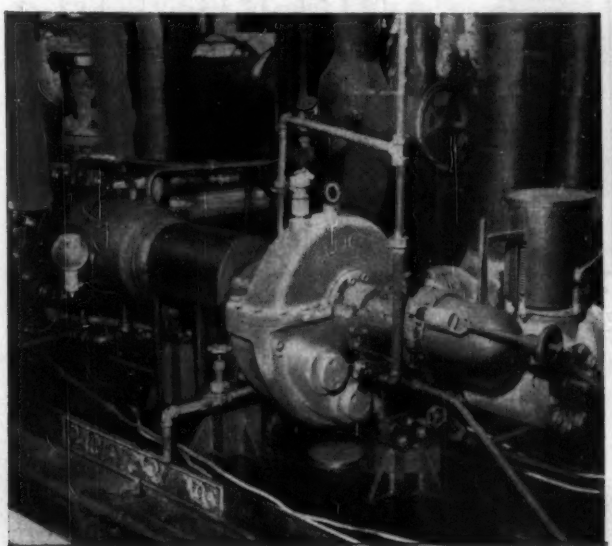
ELLIOTT serves



This Elliott 370-hp, 3240-rpm steam turbine drives a reciprocating compressor through a gear. The compressor serves a hydroformer unit.



These two Elliott 450-hp weather-protected outdoor motors, located in the bluff area near the docks, are used to drive centrifugal pumps which handle heavy naphtha from adjacent tankage.



One of eleven Elliott turbines driving centrifugal pumps at a lube oil unit.

Here an Elliott 8-in. twin strainer handles river water at a lube oil unit.

For more data on advertised products, use Readers' Service Cards, last page.

most versatile refinery

Esso Standard's Baton Rouge Refinery—producing more products than any other—is served by Elliott Turbines, Motors, Twin Strainers, Steam Ejectors, Deaerating Heaters

When this Esso Standard Oil Company refinery started operations in 1909, it processed 2000 barrels of crude oil per day into only three products. Now it converts 340,000 barrels of crude oil per day into over 600 products—a world's record in respect to number of products. It is also rated the largest refinery in the United States based on crude running capacity.

More than 100 Elliott steam turbines, ranging in size from 7 to 900 hp, are used in this refinery to drive all sorts of pumps, fans and compressors. Over a score of Elliott twin strainers, sizes 2 in. to 24 in., and Elliott steam jet ejectors serving vacuum units have been installed. Elliott 300-hp, 400-hp, and 450-hp motors are driving pumps and an Elliott 1750-hp, 1800-rpm induction motor is driving a centrifugal gas compressor. There are also four Elliott deaerating feedwater heaters.

Here is another dramatic illustration of how highest-quality steam and electrical products, manufactured by Elliott, serve leading industries. For information on how Elliott products can help you, call your nearby Elliott District Office or write Elliott Company, Jeannette, Pa.

Elliott Turbines, from small single-stage to large multi-stage types, ensure highest-quality, long-term continuous service. This typical installation, operating on a 24-hour-a-day basis, is a 460-hp, 1750-rpm Elliott turbine which drives a river water booster pump. Bulletin H-228 describes the features which have resulted in the widespread use of Elliott YR turbines.

ELLIOTT Company

Q7-1

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

For more data on advertised products, use Readers' Service Cards, last page.

"Take a tip from me—

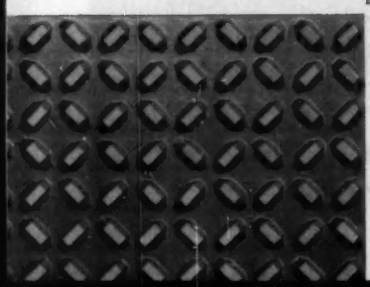
One slip can cost more than USS Multigrip"

Have you safe-treaded *all* the danger spots in your plant and on your moving equipment? Accidents may be costly—but they can be prevented. The safe tread offered by USS Multigrip Floor Plate provides positive traction in any direction.

Multigrip is studded with hundreds of little cleats shaped like those on a football player's shoe. They are flat on top—comfortable to walk on—and safe, wet or dry.

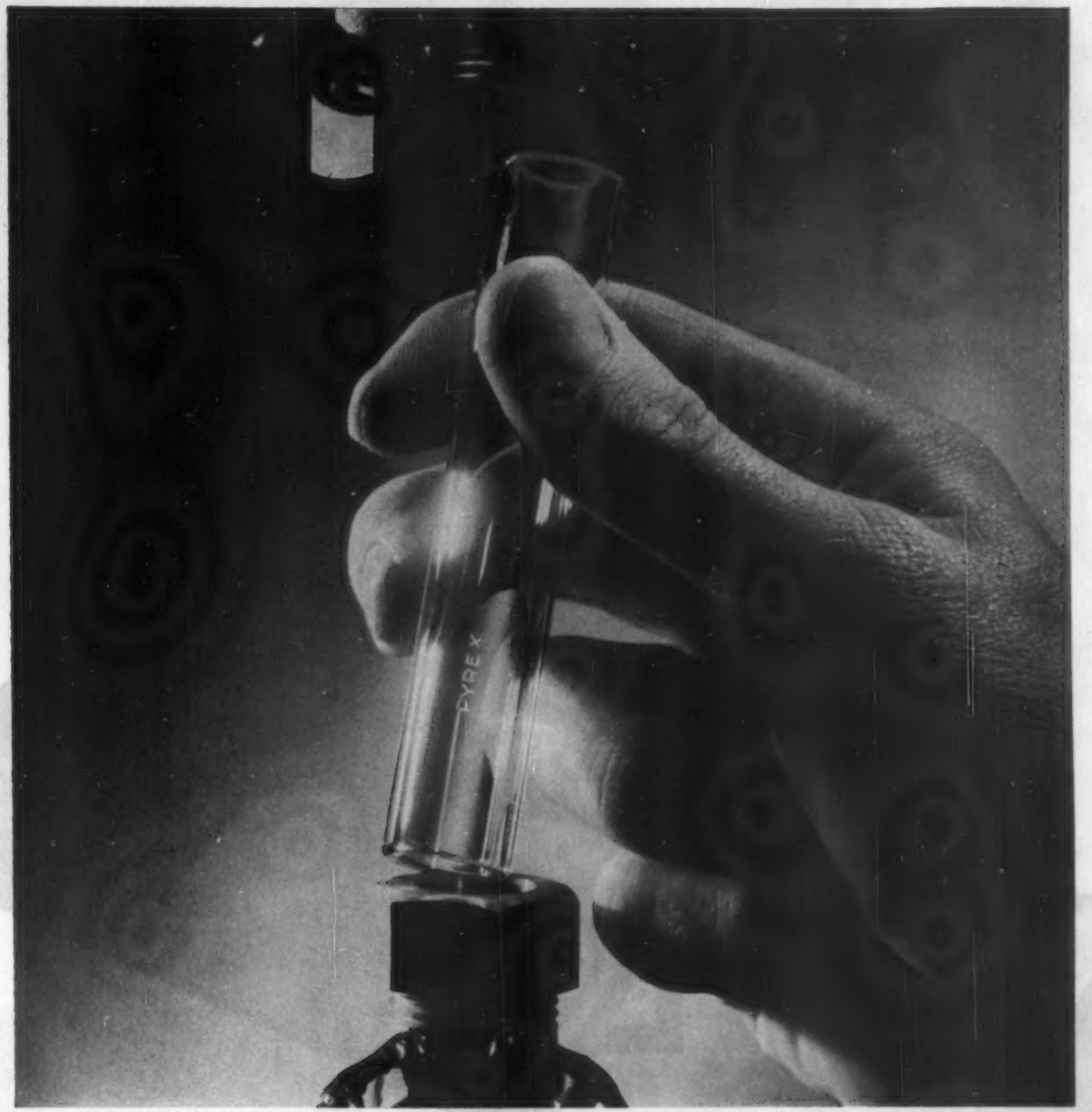
Not only does Multigrip protect workers, but it protects floor surfaces, too. It is rugged, heavy-duty steel plate that will last for years with no maintenance. It's easy to keep clean. A quick "once over" with broom or hose will get it spick and span; there are no closed pockets to hold dirt, and water drains quickly in any direction. Get Multigrip from our local distributor near you.

USS and Multigrip are registered trademarks.



Sold by leading distributors from coast to coast

USS **United States Steel**



A gauge glass installed...and two more on the shelf

Make short work of gauge glass replacement—when the replacement is as near as your stockroom shelves. You'll cut down time.

Take *three* gauge glasses the next time you order from your distributor. That gives you *one* for the gauge right away, a *second* for regular replacement, a *third* to cover special emergencies.

And here's another tip—don't rely on any old type gauge glass. Insist on regular replacement with PYREX®, CORNING®, or MACBETH® to avoid trouble.

These gauge glasses last longer—because they're harder to break! They stand up better to just about every clouding hazard. They easily resist high temperatures and high pressures.

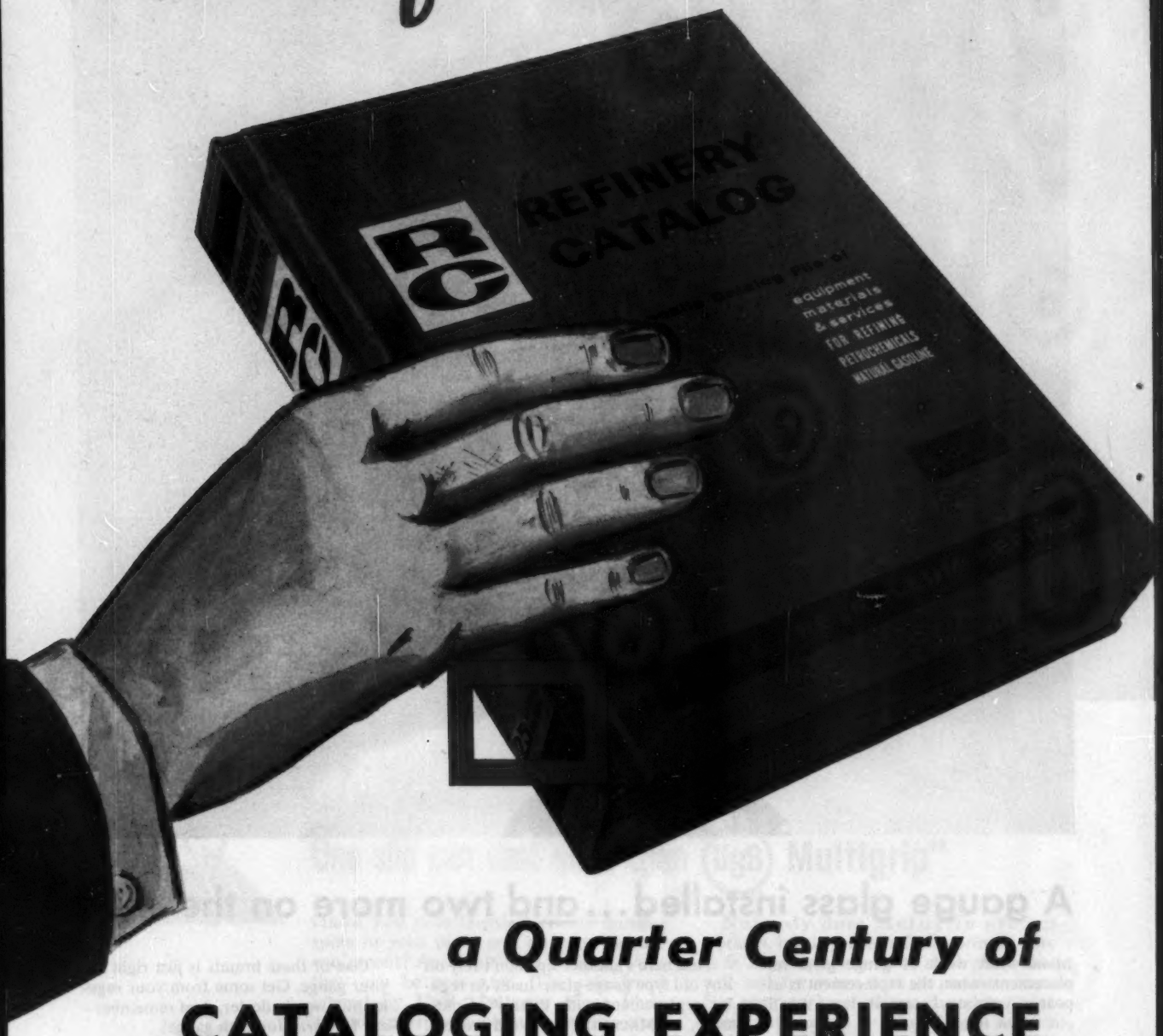
One of these brands is just right for your gauge. Get some from your regular mill supply dealer. And remember—ask for *three* for each gauge!

(Corning makes sight glasses, too—from tough PYREX brand glass. Use them whenever you must see what's going on inside your processing equipment. Your distributor has them.)

Corning means research in Glass

CORNING GLASS WORKS, Corning, N. Y.

Reach for...



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Every year for a generation executives, engineers and purchasing agents in the refining, natural gasoline and petrochemical industry have found Refinery Catalog a little more complete, a little more informative and easier to use. Preferred eight-to-one over individual sales and service bulletins, RC is the only detailed one-volume reference for complete or condensed manufacturers' catalogs, specifications, services, sources of supply.

It's conveniently indexed and cross-referenced to save you time and eliminate error. Over 300 manufacturers, suppliers and service companies listed.

For more data on advertised products, use Readers' Service Cards, last page.

BEN BUTLER (right), West Coast Production Manager, Borden Company Chemical Division. Left, Bernard Egan, Alaskan Copper & Brass Co., Cooper Alloy distributor for the Pacific Northwest.

BUTLER OF BORDEN CHEMICAL

tells why he buys COOPER ALLOY stainless steel valves

Q. Mr. Butler, why does Borden Company Chemical Division require stainless steel valves?

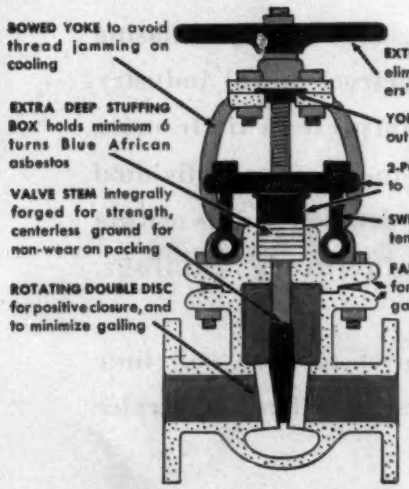
A. In the manufacture of formaldehyde, its derivative resins, and corresponding industrial adhesives only stainless steel can meet our rigid requirements for corrosion, contamination and heat resistance.

Q. What do you consider the most important factor in purchasing valves?

A. The truest measure of a valve is its operating performance. We have never received a complaint on Cooper Alloy valves from our engineers or operating personnel. The extra-large handwheel and unique valve design afford easy operation with positive opening and closing, minimizing maintenance and down time.

Q. What other factors count in choice of valve supplier?

A. Service. The large and complete Cooper Alloy stock at Alaskan Copper affords immediate delivery on stainless steel valves and fittings, as well as pipe. That's a big reason why we buy Cooper Alloy!


BOWED YOKE to avoid thread jamming on cooling
EXTRA DEEP STUFFING BOX holds minimum 6 turns Blue African asbestos
VALVE STEM integrally forged for strength, centerless ground for non-wear on packing
ROTATING DOUBLE DISC for positive closure, and to minimize galling
EXTRA LARGE HANDWHEEL to eliminate need for "persuaders"
YOKE NUT REPLACEABLE without valve disassembly
2-PC. GLAND CONSTRUCTION to prevent scoring of stem.
SWINGING EYEBOLTS for maintenance convenience
PAIRED BODY-BONNET FLANGES for equal stress and uniform gasket loading

A VALVE DESIGNED FOR STAINLESS!

The Cooper Alloy valve is not an adaptation of earlier brass and iron patterns. Cooper Alloy, with over 35 years of experience in handling stainless steel, created a valve *designed to be cast in stainless!* **Check the Special Design Features shown at left.**

As the little CA man below is saying: *"You can tell a Cooper Alloy Valve as far as you can see it!"* Write today for *your* copy of our folder "Design Factors In Stainless Steel Valves." The Cooper Alloy distributor near you will be glad to show you the complete line of Cooper Alloy valves *and fittings*, and their advantages. He can serve you promptly from local stocks.

COOPER ALLOY

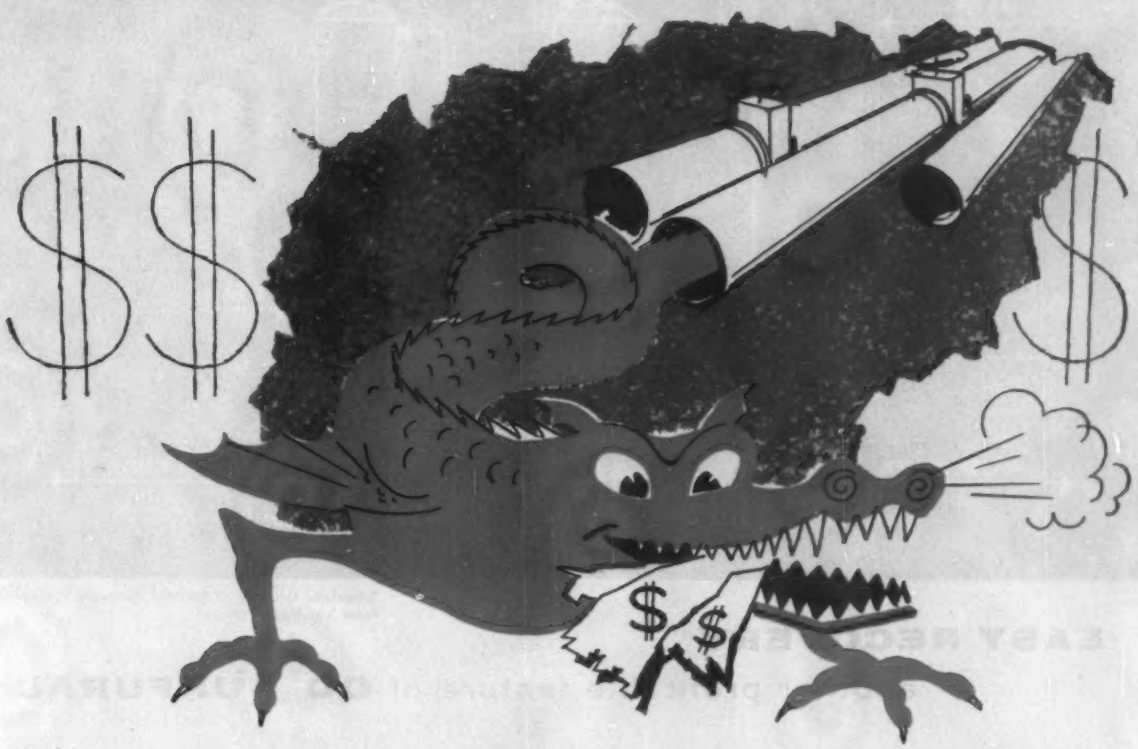
Corporation • Hillside, New Jersey

VALVE & FITTING DIVISION

THIRTY-FIVE YEARS OF STAINLESS STEEL PIONEERING

For more data on advertised products, use Readers' Service Cards, last page.

UNICOR® keeps corrosion from eating a big hole in your profits



Talk about money down the drain! Look at the ways corrosion can lose you money:

1. Reduced flow capacity means less volume handled per day. Corrosion in your pipeline takes up money-making space, reduces C factor and output.
2. Filters cost money. Take a look at your filter replacement cost sheet for the past year and you'll see what we mean.
3. Downtime for filter cleaning and replacement is a dead weight on overhead. You're not making money when you're not on stream.
4. Equipment replacements aren't cheap, either. When corrosion takes over tanks and pipelines, you're out-of-pocket for new ones.

And now look at the ways UNICOR saves your money and your equipment:

1. Unicor is a film-forming, oil-soluble inhibitor that prevents all types of pipeline corrosion. Tanks, vessels, pipelines are protected whether full, half-full or empty.
2. Unicor increases C factor to a maximum, reduces power costs, filter replacements and scraping operations.
3. Unicor costs about $0.001 (one-tenth of a cent!) per barrel of product. One molecule of Unicor to one million molecules of product gives effective anti-corrosive action.

Stop corrosion and fouling. Save money and improve product quality. Specify UNICOR for any internal pipeline corrosion problems. If you'd like to evaluate UNICOR before you send an order, write for information and samples.

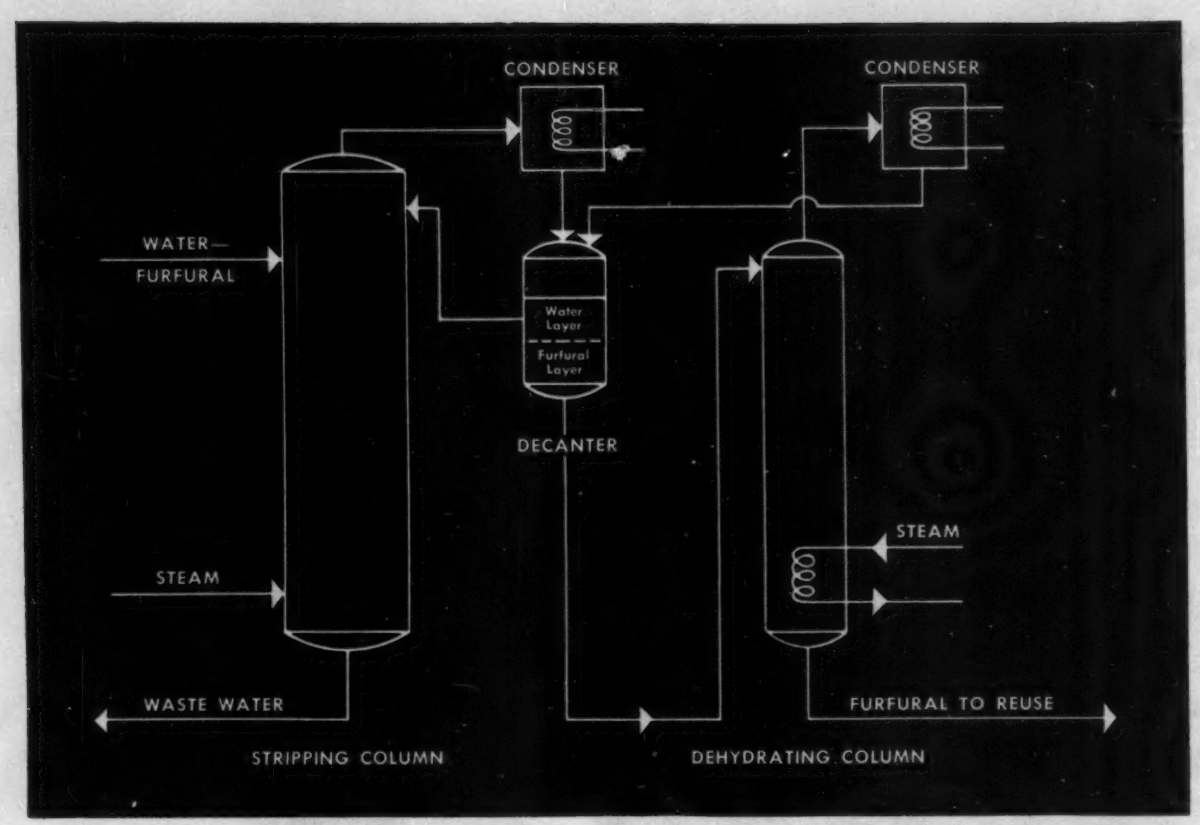
UNICOR® One of the family of superior UOP additives and inhibitors available to the petroleum industry

UNIVERSAL OIL PRODUCTS COMPANY

30 Algonquin Road, Des Plaines, Illinois, U.S.A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

For more data on advertised products, use Readers' Service Cards, last page.



Schematic Drawing of Furfural Recovery System From Aqueous Solutions

EASY RECOVERY

another profitable feature of QO® FURFURAL

High recoverability at low cost is one of the reasons for the worldwide acceptance of QO furfural as a selective solvent. For example, over-all furfural losses of less than 0.02% of the solvent cycled are reported by several lube refiners. Recovery is so good that mechanical losses ordinarily account for much of all furfural makeup required.

Illustrated above is a schematic drawing of a system for recovering furfural from aqueous solutions. Overhead vapors containing more than 8.8 weight % furfural separate into 2 layers upon cooling. At room temperature the water layer contains about 8.8% furfural and the furfural layer contains about 94.2%.

Investigate QO furfural as a selective solvent. Its proved versatility, stability and low cost add up to long, continuous plant operation, improved products and increased profits.

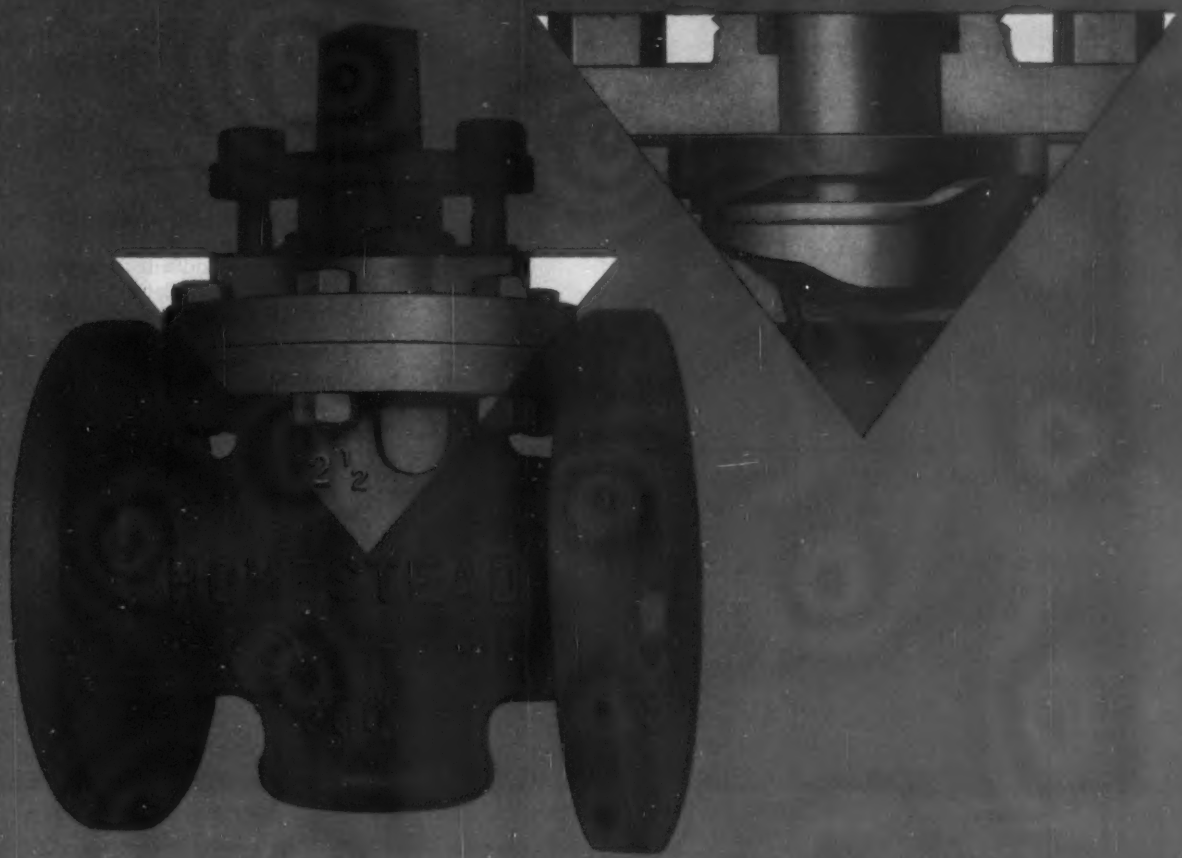
For more information about recovery of furfural from aqueous and non-aqueous systems write for our Bulletin 203-A.

The Quaker Oats Company CHEMICALS DIVISION

340B The Merchandise Mart, **Chicago 54, Illinois.** Room 540B, 120 Wall Street, **New York 5, New York.** Room 440B, 48 S.E. Hawthorne Blvd., **Portland 14, Oregon. In the United Kingdom:** Imperial Chemical Industries, Ltd., Billingham, England. **In Europe:** Quaker Oats-Graanproducten N. V., Rotterdam, The Netherlands; Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France; A/S "Ota," Copenhagen, S. Denmark. **In Australia:** Swift & Company, Ltd., Sydney. **In Japan:** F. Kanematsu & Company, Ltd., Tokyo.

In the spots that count... Homestead® Valves are

QUICK-ACTING



FASTER FLUID CONTROL is guaranteed by the quarter-turn action that fully opens or closes Homestead Cam-Seald Valves. A cam limits plug travel and automatically presses the matched seating surfaces of the plug and body together to form a leakproof, metal-to-metal seal. Additional design features such as the sealed bottom, seal between cap and body, the deep stuffing box, and the fact that fluid or grit cannot pass across the seating surface in the open or closed position, assure long, leak-free service. Write today for complete information—see how Homestead fills your needs.

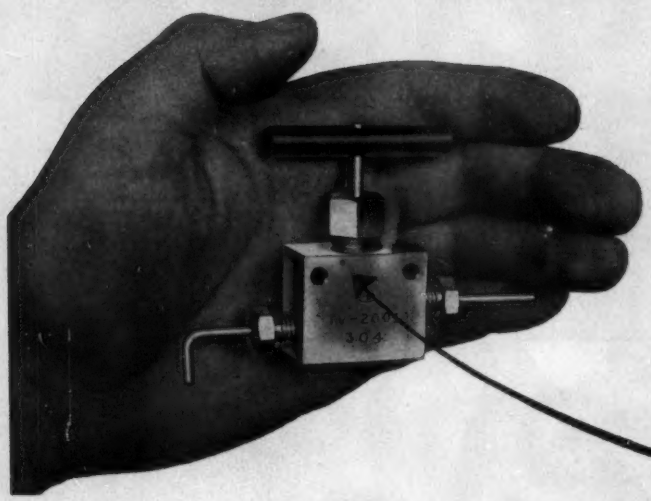
h
v

HOMESTEAD VALVE MANUFACTURING COMPANY

P. O. Box 45 Coraopolis, Pa.

On Your Instrumentation—Sampling—Bench Scale "Set-ups"

THIS 15,000 psi VALVE FOR ⅛" O.D. TUBING SAVES TIME...SAVES SPACE...SAVES MONEY

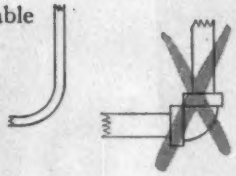


- *Made of 304 s.s.*
- *It's Safety-locked...Small... Easy To Install*
- *Eliminates Threading, Swaging, Flaring, Welding*

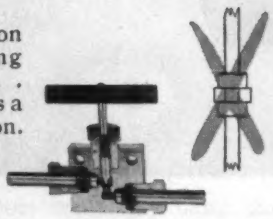
POSITIVE SAFETY LOCKING DEVICE prevents inadvertent loosening of gland nut at any time. Safety locking pin must be removed deliberately before gland nut can be loosened.

ELIMINATE COSTLY PIPING WITH TUBING and ▲ TUBING VALVES

With Tubing (available from stock)... Every bend saves a fitting and two threading operations.



With ▲ Tubing Valves... Every connection saves threading and welding... and every joint is a union connection.



Here's how you can speed up and simplify valve and fitting installations in your instrumentation, sampling, process lines and numerous other bench-scale "set-ups": USE TUBING and ▲ TUBING VALVES. The ▲ ⅛" O.D. Tubing Valve shown here, for example, is installed in three easy steps:

1—Cut tubing to desired length, deburr
2—Slip adapter nut and sleeve onto tubing
3—Insert tubing into valve and tighten adapter nut.

That's all there is to it. No threads to cut... no beveling... no swaging, flaring, welding. In a matter of seconds, you've got a gas-tight seal for pressures up to 15,000 psi. And every joint is a union connection.

Get the complete story about this valve. SEND FOR BULLETIN 857.

Autoclave Engineers
2940 WEST 22nd STREET • ERIE, PENNSYLVANIA

SCRUBOSPHERE* ...

... FOR *Cleaner Gas* AT *Less Cost!*

*PEERLESS SPHERICAL
DUST and LIQUID SCRUBBER
FOR GAS PIPELINES

(A) The majority of incoming liquid and solid particles are directed down into reservoir. 1

(B) Lighter solid particles carried by gas stream are separated on surfaces of contactor which are kept wet and clean by revolving thru liquid reservoir. 2

(C) Contactor is revolved by explosion-proof gear motor.

(D) Mist Extractor removes any remaining liquid particles from gas stream prior to outlet. 3

- **The dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes wetted surfaces for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** - The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

PEERLESS MFG. CO. DALLAS TEXAS

PEERLESS MANUFACTURING CO.

P. O. BOX 13165 DALLAS, TEXAS

Representatives in All Principal Cities

Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber.

For more data on advertised products, use Readers' Service Cards, last page.

SOLID WHEEL

spells non-stop turbine performance

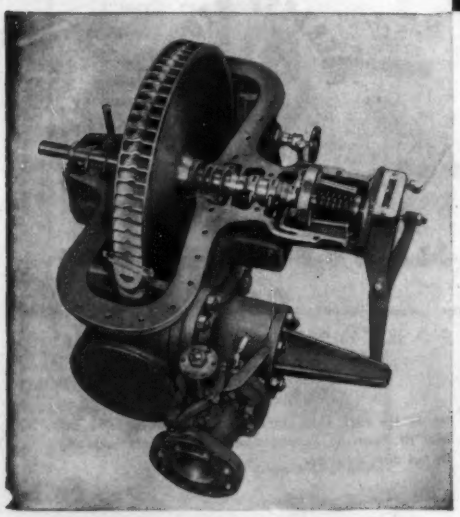
It's easy to see why Terry solid-wheel turbines have been setting non-stop records. They're built for long periods of continuous service.

The rotor, for example, is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to loosen or work out.

What's more, the blades can't foul. There is a one-inch clearance on either side of the wheel and the blades are double rim protected. There is no need for close axial blade clearance, because the steam enters the buckets at right angles to the shaft.

You, too, can profit from Terry solid-wheel stamina. Bulletin S-116 gives full details. Send for a copy today.

THE TERRY STEAM TURBINE CO.
Terry Square, Hartford 1, Conn.



Action of steam in a Terry solid-wheel turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket where its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.

TT-1205

TERRY

NOT ONE FIELD CUT

in all This MIDWEST Shop-Fabricated Piping

Under a subcon
and I would like to say the West Coast Division have on this job complied fully with the high standards of workmanship for which Midwest is known.

Throughout this entire project not once was a cut necessary to correct any piece of fabrication, and I might add in several instances close tolerances had to be met.

The above was not written on an impulse but as construction superintendent, this means but one thing: fast and low cost erection. Would appreciate your thanking Midwest personally for [illegible]om a construction

Excerpt from letter by:
HOLMES & NARVER • Engineers-Constructors
828 South Figueroa St. • Los Angeles 17

Note particularly the words "*fast and low cost erection*" in the above letter. They characterize Midwest Shop-Fabricated Piping . . . whether for refinery, power plant or industrial installations. In this instance they were written by A. H. Chamberlain, construction superintendent, upon completing the installation of a Houdriformer Unit at the U.S. Oil & Refining Co., Tacoma, Washington.

There are three well-equipped Midwest pipe fabricating shops located to serve economically all sections of the country. Each is staffed by a highly skilled organization using the latest techniques. Each has wide experience on all kinds of projects so that the possibilities and limitations of all piping materials are well understood. You too will find it to your advantage to call in Midwest whenever you need fabricated piping.

MIDWEST PIPING SERVICE IS NATIONWIDE

MIDWEST PIPING COMPANY, INC.

Main Office: St. Louis 3, Missouri (P.O. Box 443)
Plants: St. Louis, Clifton, N.J. and Los Angeles

SALES OFFICES:
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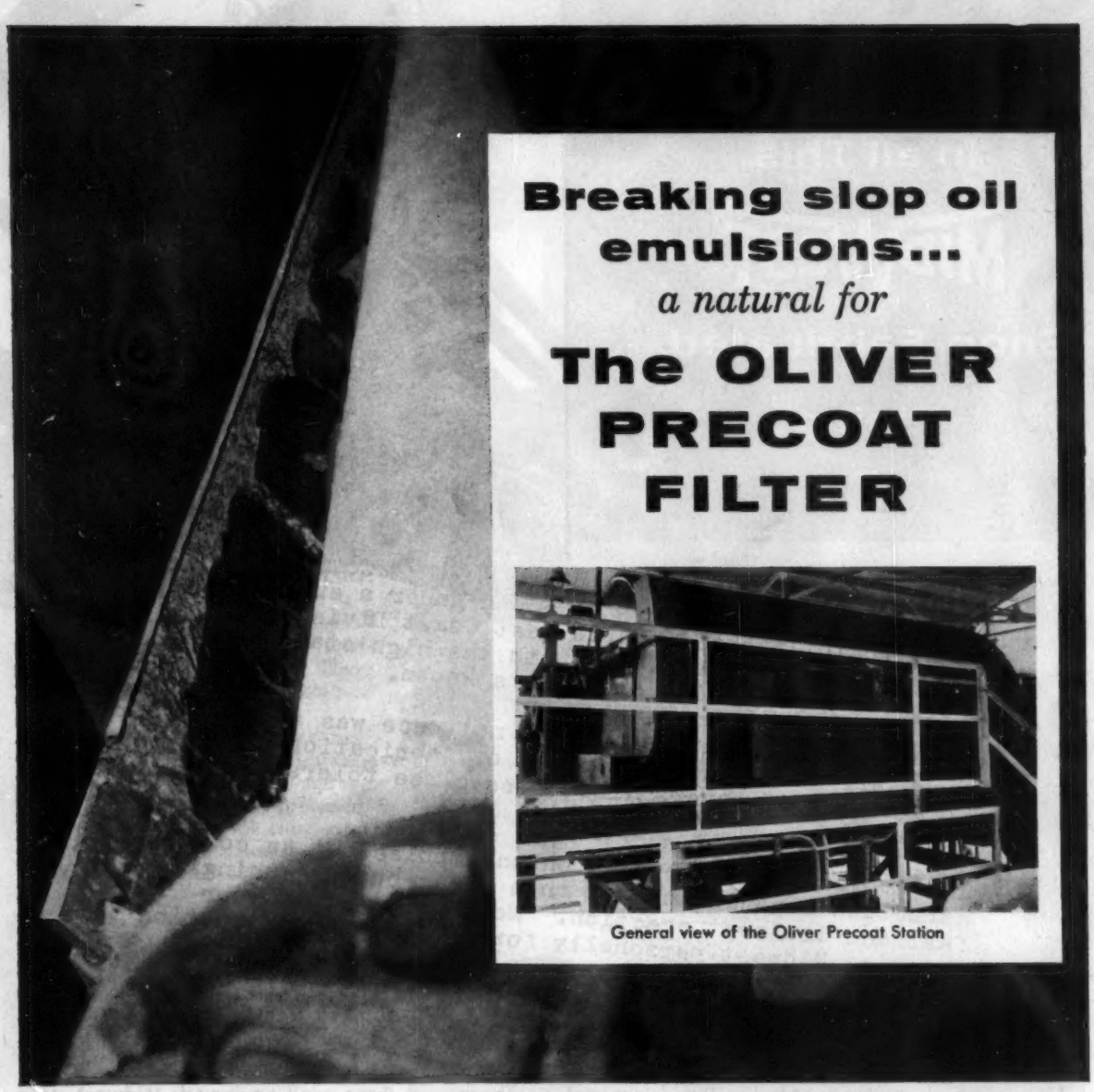
SAN FRANCISCO 11—420 MARKET ST.

8033



Breaking slop oil emulsions...

a natural for

The OLIVER PRECOAT FILTER

General view of the Oliver Precoat Station

Closeup of knife edge discharger clearly showing thin film of precoat and cake being continuously removed.

Recently installed at a large Southwestern Refinery, is another Oliver Precoat Filter for the handling of refinery slop oils.

The problem . . . continuous and economical removal of colloidal solids such as clay, coke, carbon, catalyst and some chemical emulsifiers from refinery slop oils thus permitting the separation of oil and water.

The Oliver Precoat Filter handles this heretofore considered "difficult to filter" material and delivers a filtrate which readily separates into oil and water phases.

Dorr-Oliver manufactures a complete line of filters — batch and continuous, for the petroleum industry. For more information on Oliver Petroleum Filters, write Dorr-Oliver Incorporated, Stamford, Conn.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U.S.A.

WOLVERINE
TUBE
Items of Interest to the Processing Industry

PUBLISHED BY WOLVERINE TUBE DIVISION

HOW TO LICK 3 PROBLEMS WITH 1 CONDENSER TUBE

BY ERNEST DODD

Solving three major heat transfer problems with one product is the neat trick performed recently by CALIFORNIA STEEL PRODUCTS, Division of Yuba Consolidated Industries, Inc., when fabricating a battery of six U-bend shell and tube heat exchangers for one of its West Coast customers. The units were to be used in jacket water-crude oil cooler service.

The problems: reduce unit size, slash unit costs, and increase unit service life. The product involved was electric-welded steel Wolverine Trufin® Type S/T condenser tubing in U-bend form. Here's how—and why—this product of Wolverine Tubemanship was able to help CALSTEEL accomplish its objectives.

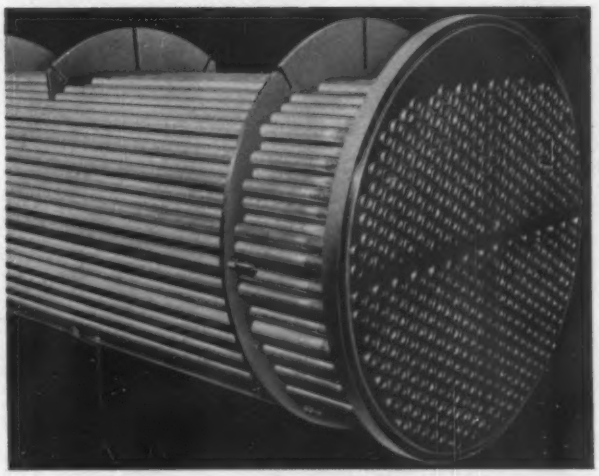
Because it is an extended surface tube with fins actually extruded from the tube wall, Trufin Type S/T has approximately 2½ times more heat transfer surface than does plain tube. It packs more heat transfer surface into a given area—permits the design of smaller and more powerful heat exchangers.

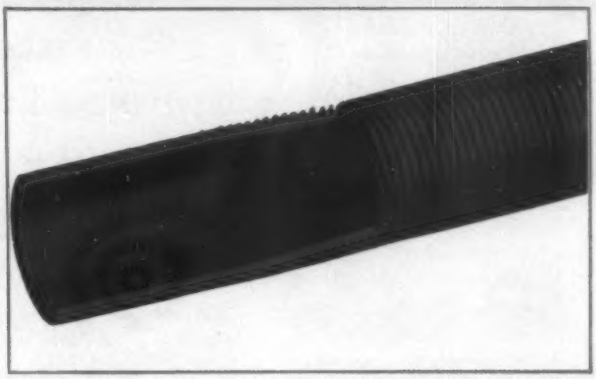
This greater surface area also means that Type S/T requires fewer tubes to handle equivalent heat duty. This means a substantial savings in direct tube costs. Fewer tubes also permit the use of smaller shells, heads and baffles with a consequent saving in material costs. This in turn brings a reduction in labor costs because of fewer rolling in operations.

Although operation of crude oil coolers is regarded as dirty service, similar applications where Trufin Type S/T electric-welded condenser tubes have been used have proven conclusively that Trufin tubed units stay on stream considerably longer than plain tube exchangers. Designers have discovered that the configuration of Trufin's extended surface is less conducive to scale build up than that of plain tube. Scaling tends to follow the contour of the fins, forming in many cases, an extended projection of the fin that contributes to self shedding. This assures reduced maintenance and increased on stream time.

In addition, CALSTEEL also helped itself to still greater savings and convenience when it specified Trufin Type S/T in U-bend form.

Wolverine pre-fabricates its U-bend condenser tubes to customer specifications—ships them in the exact order of their installation in disposable pallets. All the user has to do is insert them directly into the unit. This reduces inventory, saves floor space and cuts downtime.





Your company, too, can realize similar savings in money, time and convenience by specifying Wolverine Trufin Type S/T condenser tube. Next time you retube existing equipment or consider the design of new units, be sure to specify *Trufin*.

SEND FOR FREE BOOK

Wolverine's Trufin Catalog is filled from cover to cover with valuable information concerning integrally finned condenser tube. Processing engineers and design engineers alike will find here one of the most comprehensive sources for such finned tube data as types, sizes, alloys, end finishings, fabrication techniques, standards, and applications. Write for this valuable book today!

As Near as your Telephone

For the convenience of its customers Wolverine Tube maintains sales offices in the cities listed below. You'll find the addresses and telephone numbers listed in the yellow pages of your telephone directory. For complete information about Wolverine Trufin or other Wolverine products just call the sales office nearest you:

ALBUQUERQUE, NEW MEXICO
ATLANTA, GEORGIA
BIRMINGHAM, ALABAMA
BOSTON, MASSACHUSETTS
CHARLOTTE, NORTH CAROLINA
CLEVELAND, OHIO
COLUMBUS, OHIO
DALLAS, TEXAS
DAYTON, OHIO
DECATUR, ALABAMA
DENVER, COLORADO
DETROIT, MICHIGAN
EVANSTON, ILLINOIS
GRAND RAPIDS, MICHIGAN
HOUSTON, TEXAS
JACKSONVILLE BEACH, FLORIDA
KANSAS CITY, MISSOURI
LOUISVILLE, KENTUCKY
LOS ANGELES, CALIFORNIA
MIAMI, FLORIDA
MILWAUKEE, WISCONSIN
MINNEAPOLIS, MINNESOTA
MOLINE, ILLINOIS
NEW YORK, NEW YORK
PITTSBURGH, PENNSYLVANIA
PHILADELPHIA, PENNSYLVANIA
PHOENIX, ARIZONA
PROVIDENCE, RHODE ISLAND
ROCHESTER, NEW YORK
SALT LAKE CITY, UTAH
SAN FRANCISCO, CALIFORNIA
ST. LOUIS, MISSOURI
SEATTLE, WASHINGTON
TULSA, OKLAHOMA
WASHINGTON, D.C.

BUY WOLVERINE TUBE—IT'S MADE IN AMERICA!

CHECK THESE APPLICATIONS

Listed below are a few of the many applications where Wolverine Trufin is providing new concepts of economical heat transfer operation. Look them over and we're sure you'll find operations similar to your own.

Remember that this versatile condenser tube is available in a wide range of sizes, types and alloys in copper, aluminum and electric welded steel. It is also available in low fin form (Type S/T) for shell and tube applications and with high fins (Types H/A, H/R, L/C, I/L) for air cooled operations.

- Asphalt heater
- Reboiler
- Atmospheric section
- Light hydrocarbon condensing
- After coolers
- Heater
- Nitrogen after coolers
- Propane condensing
- Debutanizer condenser
- Ammonia condensing
- Methylchloride condensing
- Phenol cooler
- Ethyl chloride condensing
- Butalene condensing
- Freon condensing
- Toluene reboiler
- Iso Butane condensing
- Coolers
- Oil to Oil
- Steam to steam
- Oil coolers
- Gas coolers
- Inter-cooler
- Kero-coolers
- Oil heater
- Tank suction heaters
- Stripper overhead condenser
- Amine reboiler
- Debutanizer bottoms cooler
- Alcohol cooler
- Lube oil cooler
- Lean oil-rich oil exchanger

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CALUMET DIVISION
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In Canada:
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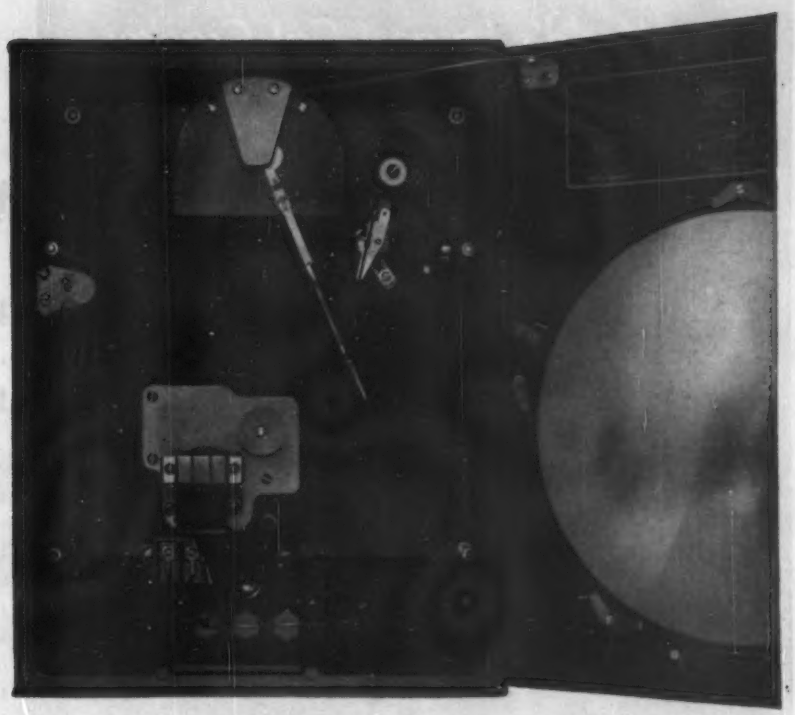
CANADA VULCANIZER & EQUIPMENT CO. LTD.
UNIFIN TUBE DIVISION

WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17236 Southfield Road
Allen Park, Michigan
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES
EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK
Wolverine Trufin is available in Canada through the Unifin Tube Co., London, Ontario.



Simplicity... you'll find it in Brown Pressure Gages and Thermometers

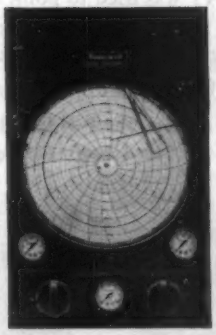
Clean, simple design—simplicity that minimizes operating or maintenance difficulties—sets Brown Pressure Gages and Thermometers apart. These rugged instruments use direct, simple linkages . . . very few parts. Basic components for both thermometers and pressure gages are interchangeable, and cases are identical.

The many narrow spans available, together with the large charts and scales, give you full use of the high accuracy of these instruments.

Brown Pressure Gages are available in many ranges, with a minimum of absolute zero and a maximum of 4,000 psi. Brown Thermometers are particularly suitable for the intermediate temperature range, extending from —125 to 1000 F.

Your nearby Honeywell sales engineer will gladly give you complete details on these instruments as they relate to your particular requirements. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.



Simplicity . . . Versatility, Too

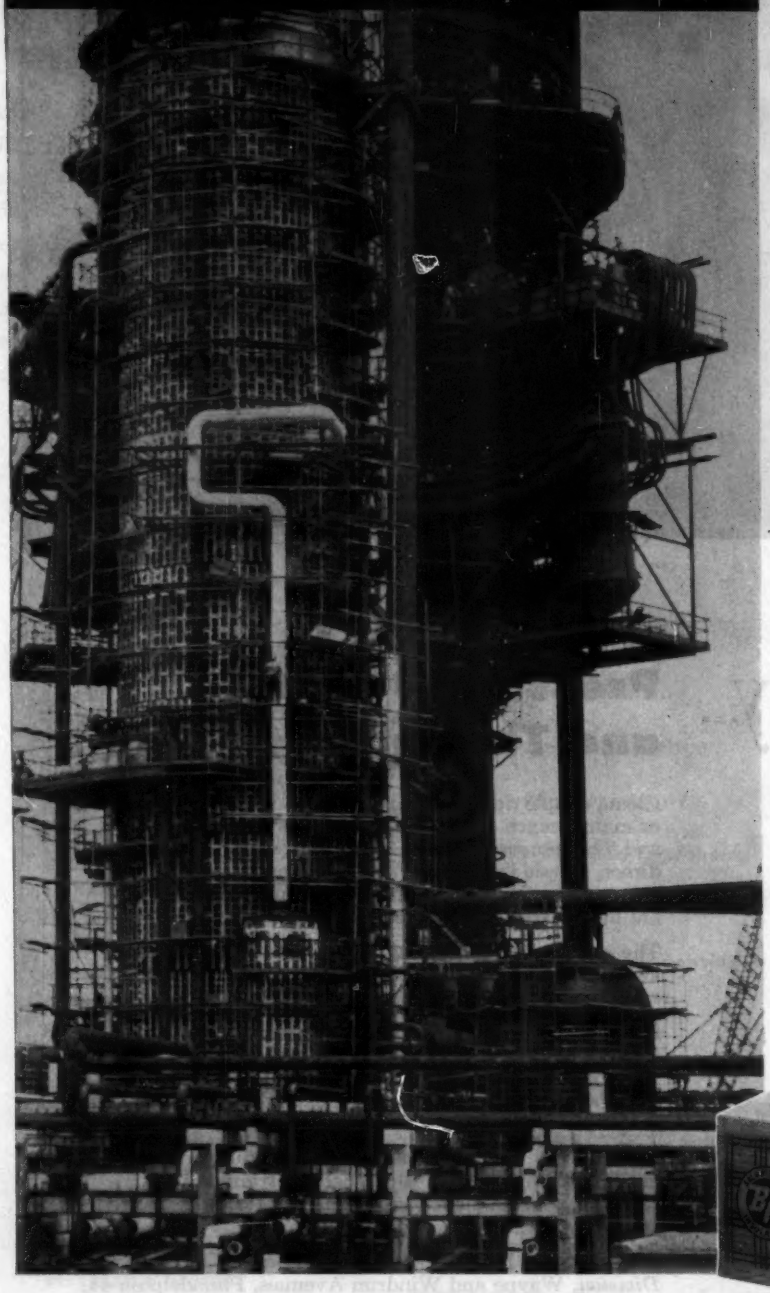
A wide variety of models, ranges and accessories are available for exact matching of Brown Pressure Gages and Thermometers to your specific applications.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

on World's Largest Cat Cracker
at Tidewater's Delaware Refinery



BALDWIN-HILL MONO-BLOCK®

prevents heat loss ...helps control temperatures

A million bd. ft. of B-H MONO-BLOCK was used on this, the largest single refinery project ever built, including the world's biggest catalytic cracking unit. It met, by a wide margin, the four primary requirements of: 1) conserving heat, 2) helping control operating temperatures, 3) protecting workers from dangerous hot surfaces, and 4) contributing to fire protection.

B-H MONO-BLOCK was selected since temperatures range from 75° to 1700° F and MONO-BLOCK provides high thermal efficiency *over this full temperature range.* By standardizing on this one-block insulation, C. F. Braun Co., Engineers and Constructors, simplified purchasing and warehousing . . . eliminating the need to stock special high temperature insulation.

B-H SUPER POWERHOUSE CEMENT was used to point all joints and as a single coat insulating-finishing cement saving the labor costs involved in two coat application.

See the B-H Catalog in Sweet's Plant Engineering File.

BALDWIN-HILL COMPANY

Complete Line of Industrial Insulations

703 Breunig Avenue Trenton 2, N. J.
Huntington, Ind. Kalamazoo, Mich. Temple, Texas

For a detailed report on the insulation of this economical installation, just staple the keyed corner of this ad to your letterhead and mail.

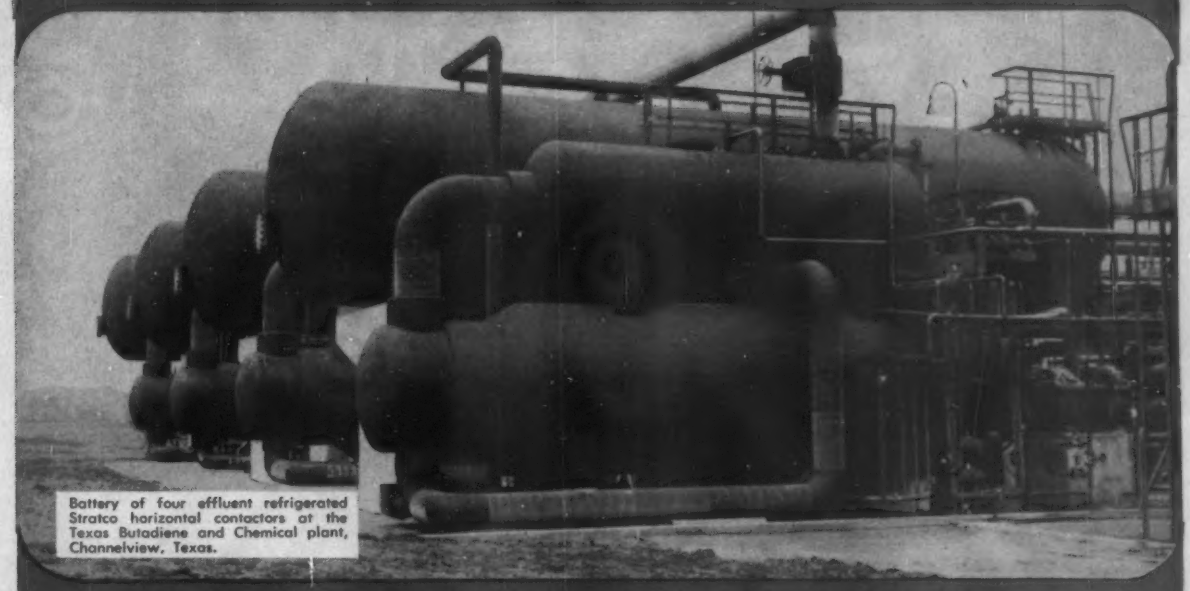
J-375

A DOMINANT FACTOR in Today's H_2SO_4 Alkylation

STRATCO

Reg. U.S. Pat. Off.

EFFLUENT REFRIGERATION PROCESS



Battery of four effluent refrigerated Stratco horizontal contactors at the Texas Butadiene and Chemical plant, Channelview, Texas.

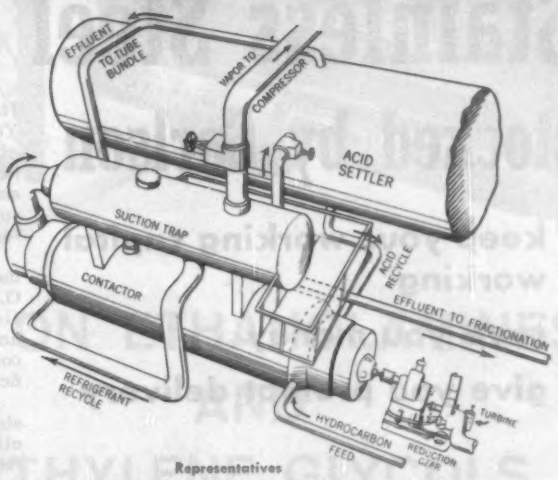
Internationally Recognized as Superior in Yield . . Quality . . Economy

Evidence of the Stratford position in H2SO4 alkylation is in the wide acceptance of the Stratco Effluent Refrigeration process. Nationally and internationally this process is recognized for its superiority in yield and quality of product, economy of acid consumption, investment and operating costs.

An amazing five year installed capacity record provides ready references as to operational capabilities. Stratco Effluent Refrigeration may be used to process propylene, butylene or amylene, either separately or as combined streams.

Electronic Computation, Too

Just send us your data for electronically computed process flow diagrams and complete over-all heat and material balances best suited to your operation . . . ordinarily available within 48 hours.



Representatives

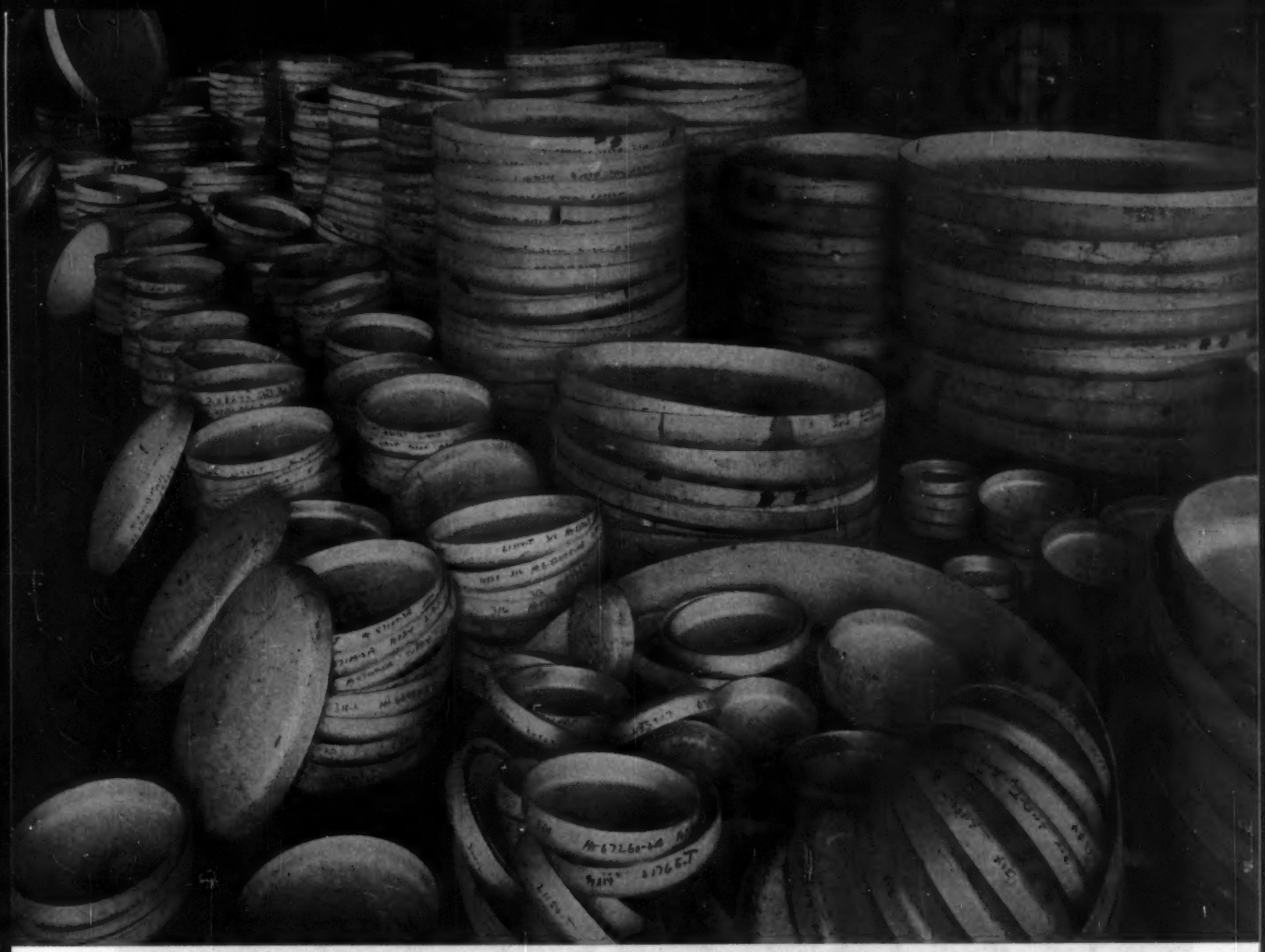
D. D. Foster Co., Pittsburg • Lester Oberholtz, Los Angeles
Rawson & Co., Houston, Baton Rouge • F. J. McConnell Co., N.Y.

Stratco Effluent Refrigeration licensed by Stratford Engineering Corporation. We cooperate with your contractor in plant design.

STRATFORD ENGINEERING Corporation

612 West 47th St. — PETROLEUM REFINING ENGINEERS — Kansas City 12, Mo.

For more data on advertised products, use Readers' Service Cards, last page.



Stainless Steel Heads

stocked by Carlson

- keep your working capital working
- save you money
- give you prompt delivery

It pays to design and build equipment with this stock in mind. You don't have to tie up your working capital in shell plates, pipe and fittings while you wait eight or ten weeks for tank heads. You'll save money by using the less expensive stock sizes that are pressed, rather than odd sizes that must be spun. You also save time when you need stainless steel heads for new construction or for emergency replacement.

The Carlson stock is made up of ASME and Standard flanged and dished stainless steel heads. They range from 10" O.D. through 72" O.D., in 6" increments, 3/16" through 3/8" Gauge, in Types 304, 304-L, 316, and 316-L. All are fully annealed and pickled after forming to provide maximum corrosion resistance. Flanges can be machined to your specifications in a matter of days.

In addition to maintaining the country's largest stock of stainless steel heads, dies are available for pressing heads in other grades of stainless. Special sizes can be spun when required. To get all the facts on this unusual Carlson service write, wire or phone for complete information.

This Carlson Stainless Steel Heads File-Folder includes lists of Dies for press forming and information on flange machining.

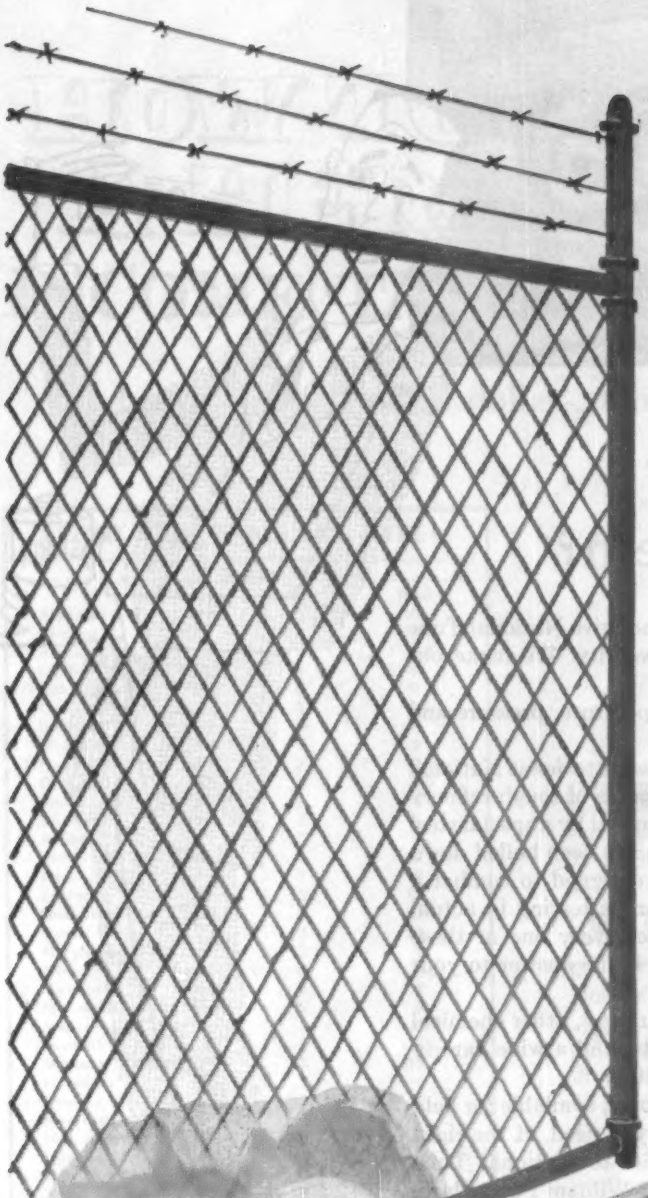
G.O.CARLSON Inc.

Stainless Steels Exclusively

THORNDALE · PENNSYLVANIA

District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)



Wherever you are, there's a distributor of Nitrogen Division ethanolamines and ethylene glycols nearby. Why not make a note right now of the one nearest you.

Local stocks of ethanolamines and ethylene glycols are maintained by the following Nitrogen Division distributors for serving the oil and gas industry:

Los Angeles Chemical Company, South Gate, Calif. . . . Cole & De Graff, San Francisco, Calif. . . . Mine & Smelter Chemical Company, Denver, Colo. . . . Acid Products Company, Inc., Chicago, Ill. . . . Mid Continent Chemical Company, South Bend, Ind. . . . Coastal Enterprises, Inc., Abbeville, La. . . . Southwest Gas Equipment Company, Liberal, Kans. . . . Thompson-Hayward Chemical Company in: Des Moines, Iowa; Wichita, Kans.; Shreveport, La.; Oklahoma City, Okla.; Tulsa, Okla.; Dallas, Tex.; Houston, Tex.; Lubbock, Tex.; San Antonio, Tex. . . . Monarch Chemicals, Inc., Minneapolis, Minn. . . . Dyce Sales & Engineering Service Co., Billings, Mont. . . . Harry A. Baumstark & Co., St. Louis, Mo. . . . George S. Coyne Chemical Company, Philadelphia, Pa. . . . T. H. Baylis Company, Providence, R. I.

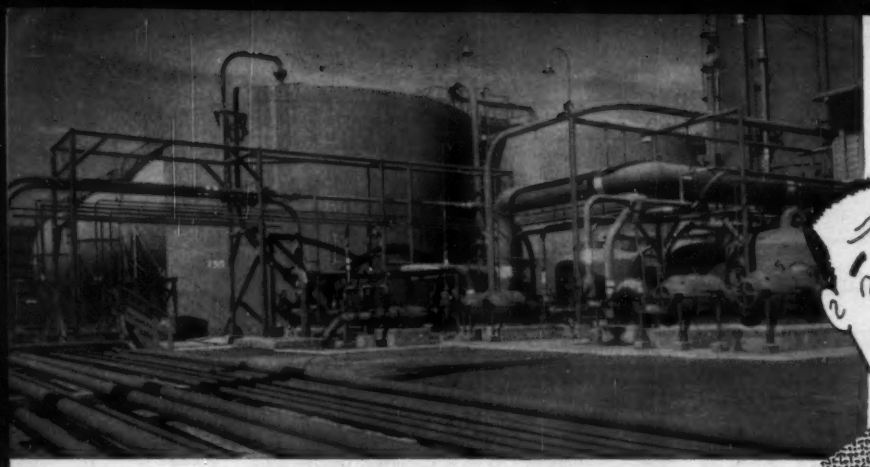
GET *FAST DELIVERY* ON ETHANOLAMINES AND ETHYLENE GLYCOLS — ANYWHERE!

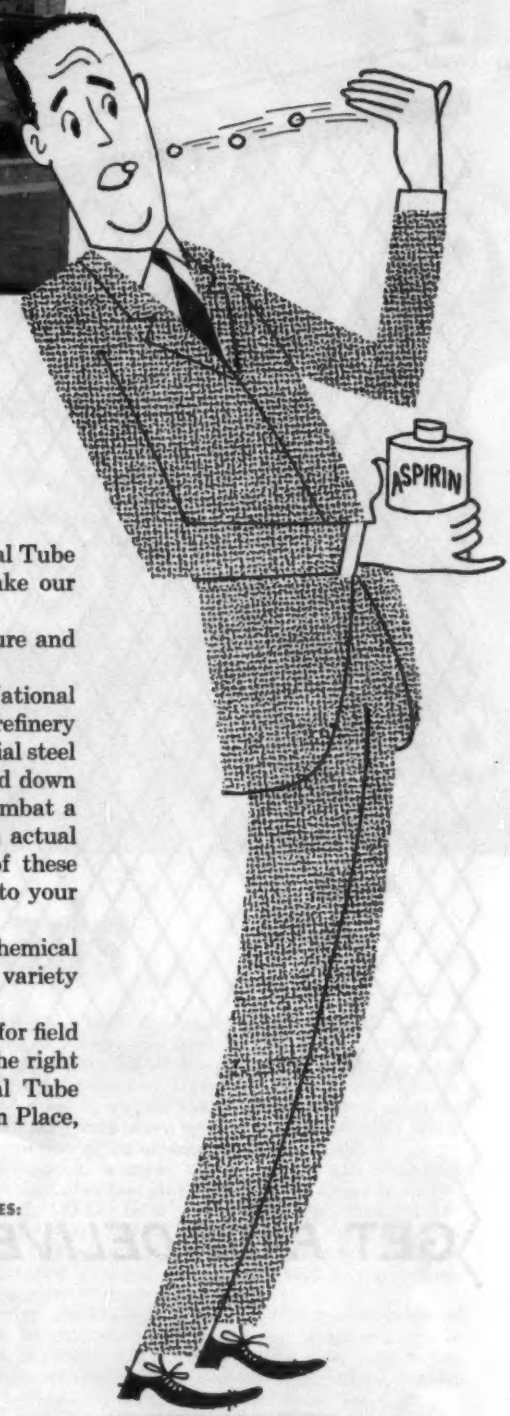
Allied Chemical

Ethanolamines • Ethylene Oxide • Ethylene Glycols • Urea • Formaldehyde • U. F. Concentrate—85 • Anhydrous Ammonia • Ammonia Liquor • Ammonium Sulfate • Sodium Nitrate • Methanol • Nitrogen Solutions • Nitrogen Tetroxide • Fertilizers & Feed Supplements

Nitrogen Division • Department GA 2-21-1 • 40 Rector Street, New York 6, New York

For more data on advertised products, use Readers' Service Cards, last page.





You say you have a corrosion problem?

BEFORE IT DEVELOPS into real trouble, why not give National Tube a call. Refinery tubing problems are our specialty. We make our living by solving them.

Corrosion problems? Acid problems? Temperature, pressure and oxidation problems? We solve them all.

How do we do it? Here's how: we've kept case histories at National Tube for over 60 years—precise data on thousands of tough refinery tubing problems. Each of these problems was solved by a special steel alloy. This accumulation of alloy information has been boiled down to 24 different steel tube analyses, each one designed to combat a specific set of refinery conditions. Long, rigorous testing in actual refinery service has proved the capabilities of every one of these analyses. We feel confident that one of them is the answer to your problem.

In addition to the two dozen analyses shown here, other chemical compositions are available in tubular products, and a wide variety of temperature problems is presently under study.

So, get in touch with us. Our Mill Service Force, available for field consultation, will help you find just the alloy you need, at the right price, to meet your refinery conditions. Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

HERE ARE NATIONAL TUBE'S TWO DOZEN DIFFERENT TUBE ANALYSES:

Carbon	5 Cr, ½ Mo	17 Cr
Carbon, ½ Mo	5 Cr, ½ Mo, 1½ Si	18-8
1 Cr, ½ Mo	7 Cr, ½ Mo	18-8 Ti
1¼ Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
2 Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo
2¼ Cr, 1 Mo	9 Cr, 1 Mo	25-20
2½ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
3 Cr, 1 Mo	12 Cr, Al	5 Ni

National Tube Division of USS United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors · United States Steel Supply Division · United States Steel Export Company, New York

HOW TO BE A HERO AT INCOME TAX TIME

(And save yourself a few dollars, too!)

STEP #1 **Just tell your friends** that their state gasoline taxes can be deducted on their Federal Income Tax. (Other taxes, such as state and local sales taxes, may also be deducted but under a different formula.)

STEP #2 **It's so easy.** You'll find your state gasoline tax on the tax list on this page. Multiply that by the number of gallons purchased in 1957.

STEP #3 **Here's an example:** Friend "A" drove 10,000 miles last year and got 14 miles per gallon. That's 700 gallons of gasoline. Say your state tax rate is 6¢ a gallon. 700 times 6¢ is $42. So friend "A" gets a $42 deduction on his Federal Income Tax. You're a hero! And you've made a friend for your industry!

You can make even more friends for your industry when you tell people that they drive a bargain with today's gasoline. The price of gasoline itself has gone up only 17% in the last decade while taxes have gone sky high. For every dollar they spend on fuel itself, they spend an additional 40¢ in federal and state taxes. Mail the coupon below for more information about today's gasoline.

FIND YOUR STATE TAX HERE!

Based on tax rates as of October 1, 1957 (in cents per gallon).

	State	Federal	Total
Alabama	7	3	10
Arizona	5	3	8
Arkansas	6.5	3	9.5
California	6	3	9
Colorado	6	3	9
Connecticut	6	3	9
Delaware	5	3	8
Dist. of Col.	6	3	9
Florida	7	3	10
Georgia	6.5	3	9.5
Idaho	6	3	9
Illinois	5	3	8
Indiana*	6*	3	9
Iowa	6	3	9
Kansas	5	3	8
Kentucky	7	3	10
Louisiana	7	3	10
Maine	7	3	10
Maryland	6	3	9
Massachusetts*	5.5*	3	8.5
Michigan	6	3	9
Minnesota	5	3	8
Mississippi	7	3	10
Missouri	3	3	6
Montana*	7*	3	10
Nebraska*	7*	3	10
Nevada	6	3	9
New Hampshire*	6*	3	9
New Jersey	4	3	7
New Mexico	6	3	9
New York (State)	4	3	7
N. Carolina	7	3	10
N. Dakota	6	3	9
Ohio	5	3	8
Oklahoma*	7.5*	3	10.5
Oregon	6	3	9
Pennsylvania*	5*	3	8
Rhode Island	4	3	7
S. Carolina	7	3	10
S. Dakota*	6*	3	9
Tennessee	7	3	10
Texas	5	3	8
Utah*	6*	3	9
Vermont*	6.5*	3	9.5
Virginia	6	3	9
Washington	6.5	3	9.5
W. Virginia	6	3	9
Wisconsin	6	3	9
Wyoming	5	3	8
U. S. Average	5.8	3	8.8

*Changes during year: Ind.—tax was 4¢ before 3/15/57; Mass.—tax was 5¢ before 6/1/57; Mont.—rate will be 6¢ effective 1/16/58; Neb.—rate was 6¢ before 9/20/57; N. H.—tax was 5¢ before 9/1/57; Okla.—rate which was increased on 6/1/57 dropped back to 6.5¢ by 12/31/57; Penn.—tax was 6¢ before 6/1/57; S. D.—tax was 5¢ before 7/1/57; Utah, tax was 5¢ before 5/14/57; Vt.—tax was 5.5¢ before 7/15/57.

American Petroleum Institute, Dept. G
50 W. 50th Street, New York 20, N. Y.

I would like to obtain more information about today's gasoline quality, prices and taxes. Please send me your FREE booklets.

NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

For more data on advertised products, use Readers' Service Cards, last page.

Austin-Western Hydraulic Crane lowering section of pipe upon a flat bed truck. Superstructure in background is one of the flashing units at Wood River Refinery, Roxana, Ill.

Austin Western hydraulic crane speeds repairs at Shell's Wood River Refinery

Shell's Wood River Refinery, Roxana, Ill., had six larger cranes, yet in 1955 purchased an Austin-Western for faster handling of 5-ton loads and less.

The company reports: "This crane with its 16-in. tires, four-wheel power steer and four-wheel drive saves time in pulling exchanger tubes and getting around pump houses. With it the men remove heads of heat exchangers, a job that formerly required a large crane, which was more expensive to operate or called for chain blocks which took more men at increasing labor rates. Maintenance men request this hydraulically controlled and maneuverable light crane to lift and transport pumps into the machine shop for repair. It can set a pump right on a boring mill, for instance, without additional handling."

Moves right up to the work. "Being low slung, the A-W goes under the lines in the pipe alleys where larger equipment could not pass. . . . With its 12-ft. extension added to the 18-ft. extensible boom, this crane can remove pump parts through a window section at second story height and later replace them. When a shaft or impeller requires repair in such a location the A-W saves a great deal of hand rigging and consequently many man-hours of time."

Sometimes works around the clock. "Any one of 10 cranemen may be called on to handle the A-W. In the busy season of the year it is sometimes used 7 days a week, right around the clock. . . . It is likely to handle a dozen jobs in 8 hours. . . . New uses for this versatile crane are being [continually] found."

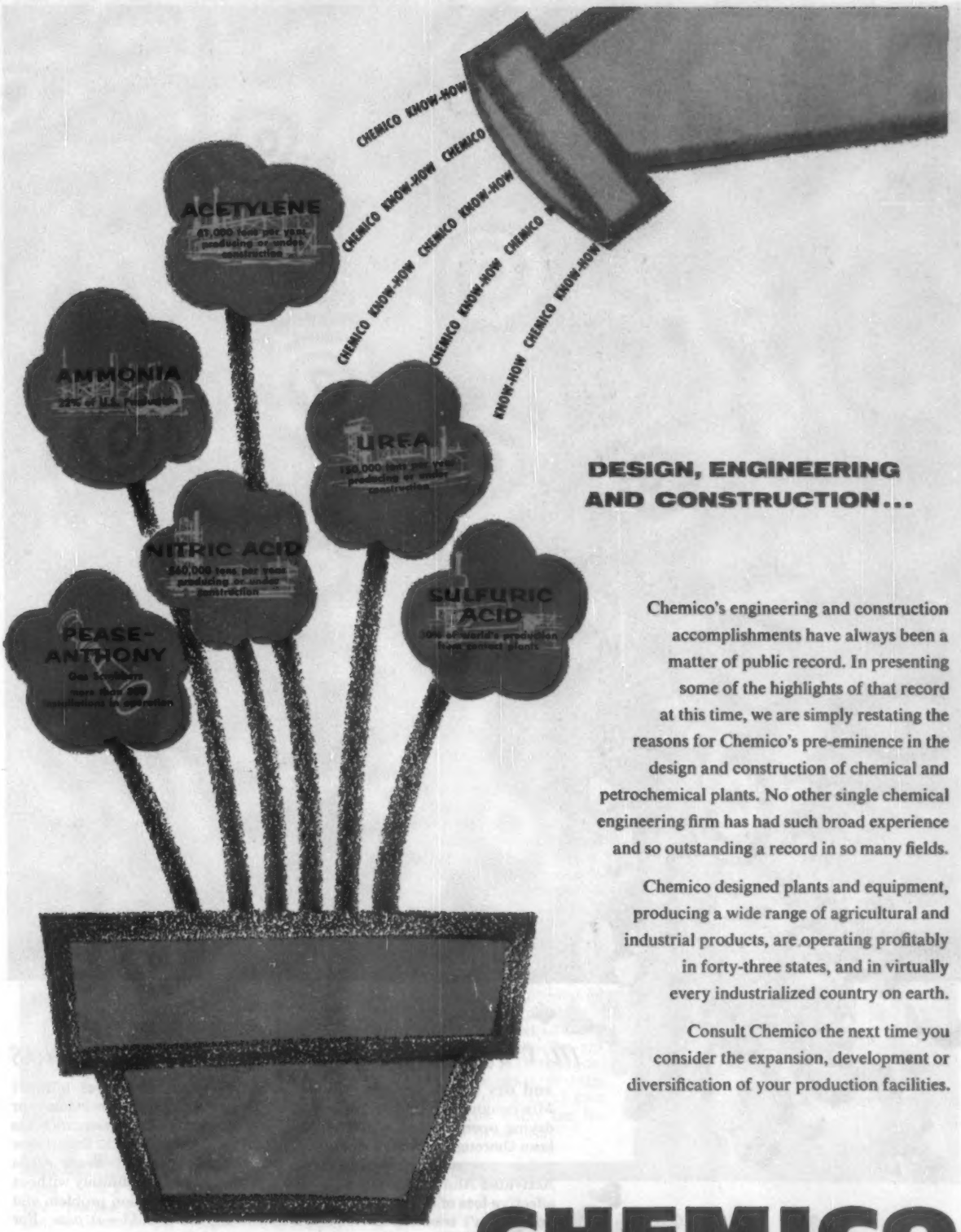
Low cost operation. "The operating cost of this crane is about what other users report for 8 hours' daily use — less than one man's wages."

Get the full story at Shell
Write for Certified Gould Report No. 5612

Austin-Western CONSTRUCTION EQUIPMENT DIVISION, AURORA, ILL.

BALDWIN · LIMA · HAMILTON

Power graders • Motor sweepers • Road rollers • Hydraulic cranes



DESIGN, ENGINEERING AND CONSTRUCTION...

Chemico's engineering and construction accomplishments have always been a matter of public record. In presenting some of the highlights of that record at this time, we are simply restating the reasons for Chemico's pre-eminence in the design and construction of chemical and petrochemical plants. No other single chemical engineering firm has had such broad experience and so outstanding a record in so many fields.

Chemico designed plants and equipment, producing a wide range of agricultural and industrial products, are operating profitably in forty-three states, and in virtually every industrialized country on earth.

Consult Chemico the next time you consider the expansion, development or diversification of your production facilities.

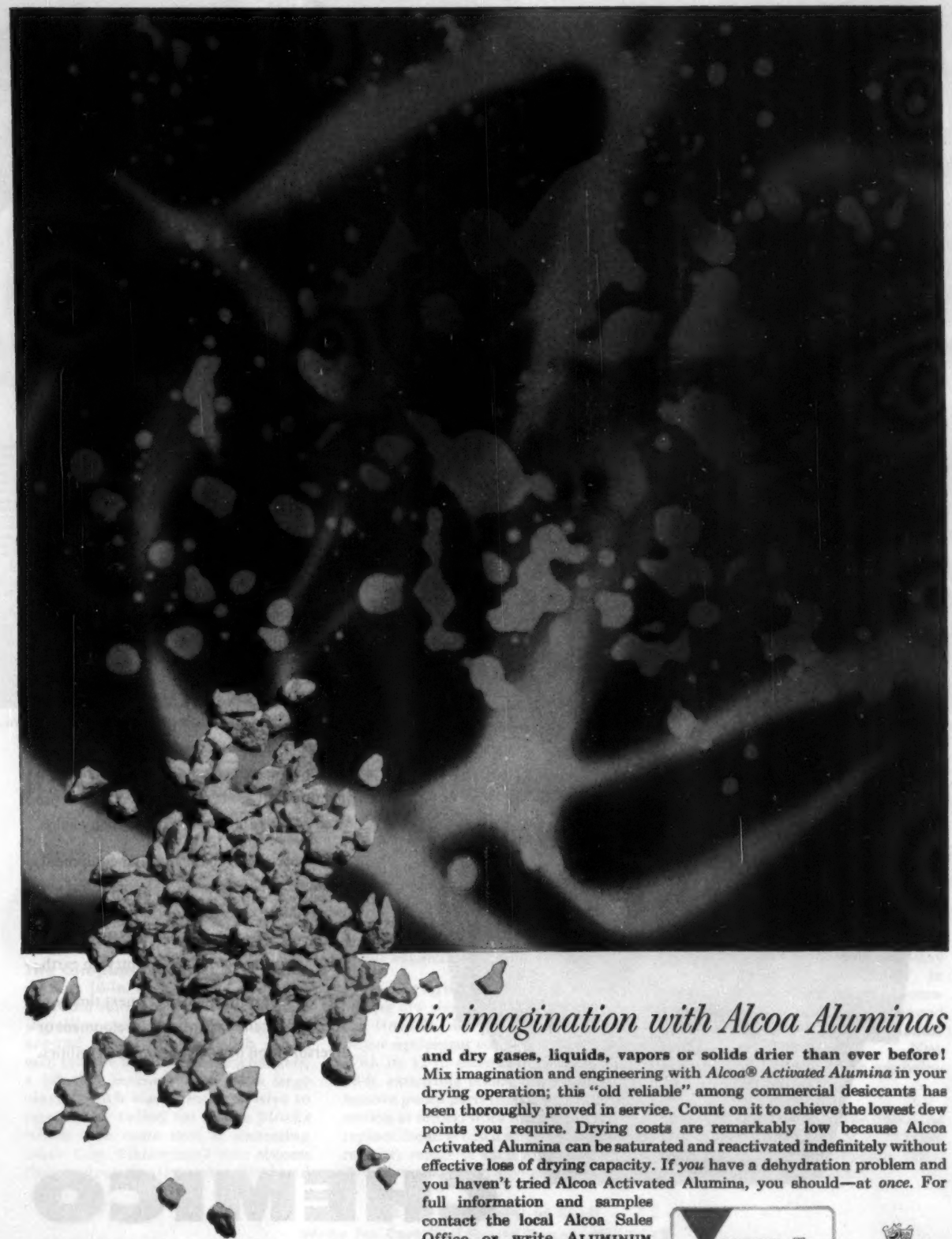
CHEMICO

CHEMICAL CONSTRUCTION CORPORATION

A SUBSIDIARY OF ELECTRIC BOND AND SHARE COMPANY

525 West 43rd Street, New York 36, N. Y. • Cable Address: CHEMICONST, New York

CHICAGO • DALLAS • PORTLAND, ORE. • TORONTO • LONDON • PARIS • JOHANNESBURG • TOKYO



mix imagination with Alcoa Aluminas

and dry gases, liquids, vapors or solids drier than ever before! Mix imagination and engineering with *Alcoa® Activated Alumina* in your drying operation; this "old reliable" among commercial desiccants has been thoroughly proved in service. Count on it to achieve the lowest dew points you require. Drying costs are remarkably low because Alcoa Activated Alumina can be saturated and reactivated indefinitely without effective loss of drying capacity. If *you* have a dehydration problem and you haven't tried Alcoa Activated Alumina, you should—at *once*. For full information and samples contact the local Alcoa Sales Office or write ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 717-C Alcoa Building, Pittsburgh 19, Pa.

ALCOA CHEMICALS
ALUMINUM COMPANY OF AMERICA

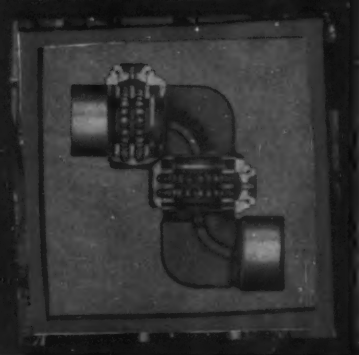
"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

For finer products . . . let Alcoa add new directions to your creative thinking!

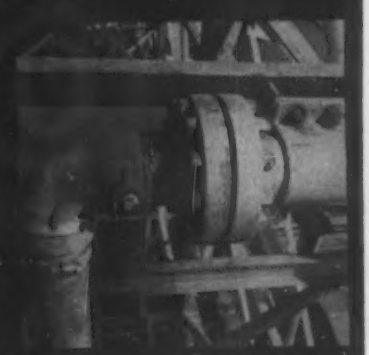
For more data on advertised products, use Readers' Service Cards, last page.

CHIKSAN HELPS UNION OIL CUT OUT THE COKE

Swiveling Chiksan Decoking Arms combine flexibility and stamina to handle 1700 psi hydraulic water force used to remove petroleum coke from coke drums



During refining of crude stock at Union Oil's Oleum refinery, petroleum coke is produced as a valuable by-product. When coke drums become full, they are "decoked" with a high pressure water jet which first drills out a pilot hole, then cuts the coke loose, moving it out of the tower in slurry form. Safety dictates all metal flexible lines. The solution—Chiksan Swivel-Jointed All Steel Decoking Arms. These rugged units provide free turning rotation with all movement carried out in a predetermined arc. Service life of the Chiksan Decoking Arms is measured in years and maintenance involves an occasional packing replacement. If your equipment or plant lines require flexibility, let Chiksan swivel joints provide the answer with less maintenance, limited replacements, and the safety that only steel can provide. Write today for literature and price lists.



LOOK INSIDE A SWIVEL JOINT. Detailed attention to detail. Precision machining and specific packing seals for specific services. These are the quality-plus features built into every Chiksan Swivel Joint.

fmc CHIKSAN

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

CHIKSAN COMPANY—BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg Corp (Division), Houston 1, Texas • Subsidiaries Chiksan Export Company • Chiksan of Canada Ltd.

#57-29

Smith "Figure 800"
O S & Y Gate Valve
Sizes: ¼" - 2" incl.

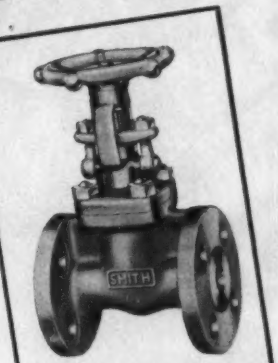
(at left)
Smith "Figure 850"
Inside Screw Valve
Sizes: ¼" - 2" incl.

something to Crow about!

Smith FORGED STEEL Valves

SMITH Forged Steel Valves are now in use in a large percentage of the major Refineries, Chemical and Petrochemical plants in this country and Canada. Their rapidly growing use by these industries is not just the result of salesmanship. It is, rather, a matter of acceptance based on proven performance — the ability to meet the challenge of ever-increasing temperatures, pressures and corrosion — to give longer, trouble-free life in service.

In the few short years since their introduction to the market, SMITH Valves have gained such a wide-spread reputation for long-lasting performance that we think we have "something to crow about."



Smith "Figure 815"
Flanged End Gate Valve
Sizes: ½" - 2" incl.

Write today for our new catalog, giving complete information on our entire valve line

NEW ENGLAND VALVE Corporation

P. O. BOX 1047 • WORCESTER, MASSACHUSETTS

West Coast Distributors: BETHLEHEM SUPPLY CO., LOS ANGELES, CALIFORNIA

BRIDGEPORT BRASS
COPPER ALLOY BULLETIN
CONDENSER AND HEAT EXCHANGER TUBE EDITION

Inlet end of first pass of heat exchanger blocked by trash.

Cleaning Methods that Insure Longer Tube Life and Greater Operating Efficiency

The high cost of foreign matter in condenser tubes is all too well known. Slime, marine organisms, silt, cinders and trash —all create the common costly problems of decelerated heat transfer and accelerated corrosion.

An effective tube-cleaning program is of prime importance in helping to keep operating costs at economical levels. As with all conditions of heat exchanger and condenser tube operation, cleaning methods vary in virtually each situation, depending, of course, on the nature of contamination.

In some applications rubber plugs are found to be effective. Brushes and scrapers, too, shot through the tubes by compressed air or water can clear lodged debris. Sometimes, these methods are not wholly satisfactory; the presence of stubborn debris may call for "rodding." Maintaining strainers and using rotating or stationary screens are preventive maintenance aids that pay dividends.

Scale Removal

The use of acids or strong alkaline solutions, which are inhibited to reduce corrosion of the tubes, can often dissolve or loosen scale or slime on the tube walls. Here, again specifics must be known before the correct cleaning solution can be formulated to effectively solve the problem. Very important is the alloy itself; full familiarity with its chemical make-up is essential so that the cleaning solution attacks only the scale and not the metal.

Slime Prevention

A properly set-up schedule of chlorination is highly effective against the formation of slime on tube walls. Water characteristics must be taken into account before the correct concentration of chlorine in the water can be arrived at. Over-chlorination can result in accelerated corrosion by rupturing the protective film on the tube surface. When the chlorination procedure is satisfactory, a red-brown or amber-colored film forms on the tube surface. Slime decomposition also can lead to the formation of ammonia, particularly during shutdown or stand-by, which may initiate stress corrosion-cracking of copper alloys with a high zinc content.

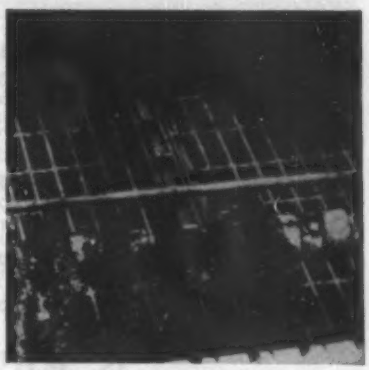
Biofouling

Biofouling organisms should be promptly removed from the tube surface by persistent scrubbing with a stiff brush and water. When these organisms die and dry on the tube surface it is doubly difficult to remove them, especially those with calcareous bases such as barnacles. When allowed to remain, the decomposition products of these organisms destroy the corrosion film and thus create a focal point for corrosion pitting. Increasing water velocity, when feasible, prevents the organisms from getting a fast hold, and is often helpful in reducing tube corrosion and maintaining heat transfer.

Biofouling in unchlorinated sea water.

Bridgeport Technical Service

You can always get help on your cleaning problems from Bridgeport Technical Service. Our familiarity with heat exchanger and condenser tube operation—under all conditions of contamination, both at sea and ashore—can help in analyzing your specific cleaning problem and result in a cleaning procedure that will help your tubes "live longer." For any information on the subject of tube hygiene, write or call the Bridgeport Sales Office nearest you.



Control of biofouling by chlorination of sea water.

BRASS Bridgeport CO.

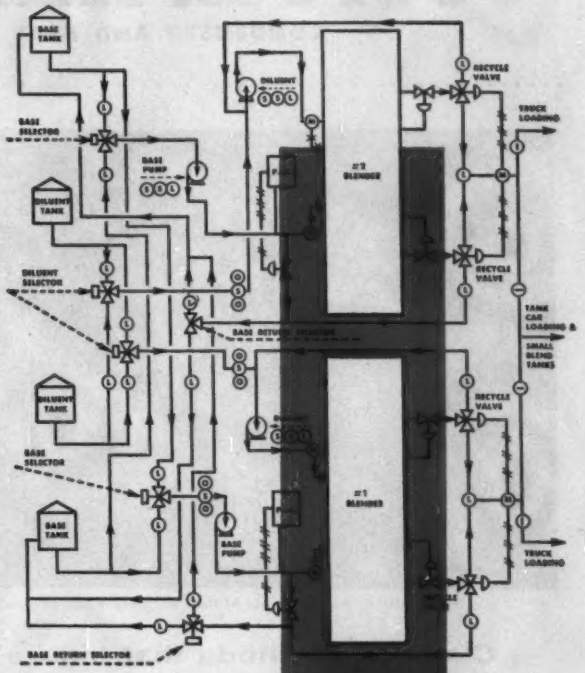
BRIDGEPORT BRASS

Bridgeport Brass Company, Bridgeport 2, Conn. • Sales Offices in Principal Cities
In Canada: Noranda Copper and Brass Limited, Montreal

For more data on advertised products, use Readers' Service Cards, last page.

POSITIVE CONTROL OF MATERIALS IN MOTION B-I-F

Phillips 66



At Phillips'
Wood Cross (Utah) Refinery . . .

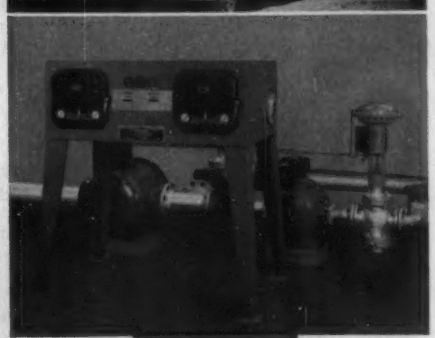
SINGLE-PASS ASPHALT BLENDING

Streamlines Cutback Shipments!

With the booming market for paving asphalts requiring "around-the-clock" loading at the Woods Cross Refinery, Phillips is proving the advantages of Proportioneers continuous, automatic in-line blending equipment. This system permits personnel . . . without leaving the loading dock . . . to line up the proper asphalt and cutter stock, to set and reproduce any required blend, and to load the road oil (as a stable end product of predetermined viscosity) in a single operation . . . directly to mobile equipment.

This Proportioneers system reduces any fire hazard, loss of time and materials, and the need for reblending and subsequent mixing. The two Proportioneers Two Component Blenders were furnished as "packaged" units, complete with control system, flow meters, strainers, and control valves.

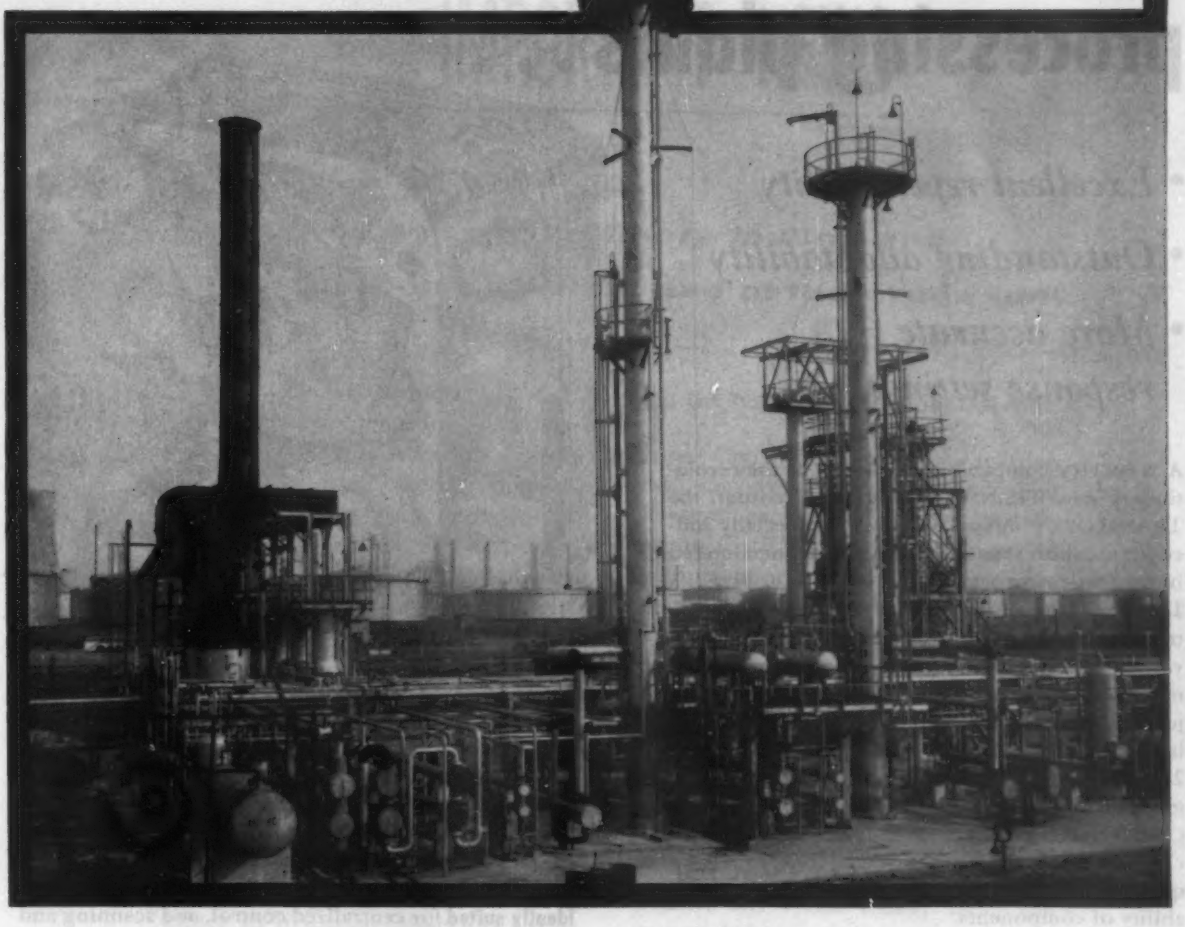
Streamline your asphalt operation for maximum production. Request Bulletin DM-1 for complete data. Write **Proportioneers, Inc., 41½ Harris Ave., Providence 1, R. I.**



PROPORTIONEERS
DIVISION OF
B-I-F INDUSTRIES
METERS FEEDERS CONTROLS

In Britain...

ANOTHER JOB WELL DONE by PROCON



At home or abroad, wherever you need to build, Procon offers the finest construction service. This 800 B/SD Platforming® unit was built by Procon (Great Britain) Limited. The unit was designed to produce an 85 to 90 RON clear product from Kuwait naphtha or a 90 to 95 RON clear blending component from mixed Peruvian naphthas. The Platformer construction included a prefractionator to separate naphtha from full-range gasoline or to prepare a 53-150°C. naphtha for Platforming feed from Peruvian stock.

In England, as in all other parts of the free world, Procon is serving the petroleum, petrochemical and chemical industries with better plant design and construction.

If you want a job done, and done right, anywhere in the world...

Call on PROCON

PROCON *Incorporated*

1111 MT. PROSPECT ROAD, DES PLAINES, ILLINOIS, U. S. A.

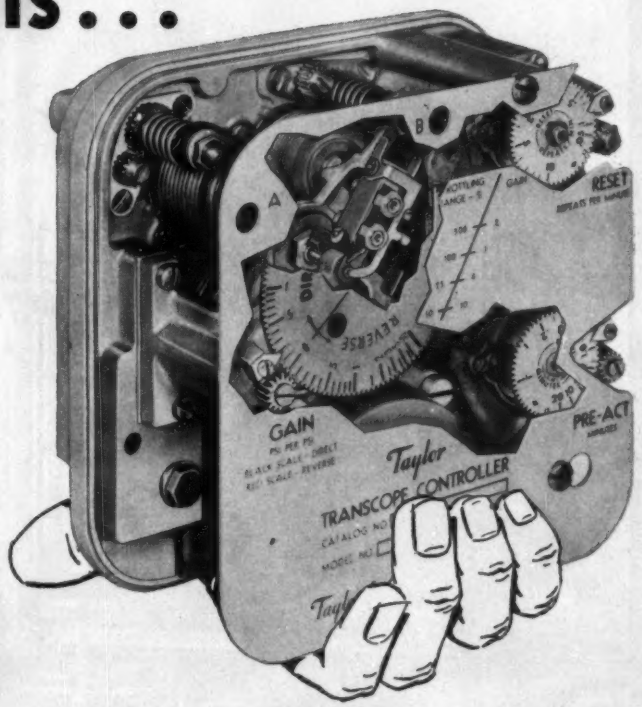
PROCON (CANADA) LIMITED, TORONTO 18, ONTARIO, CANADA
PROCON (GREAT BRITAIN) LIMITED, LONDON, W. C. 2, ENGLAND
PROCON INTERNATIONAL S. A., SANTIAGO DE CUBA

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

For more data on advertised products, use Readers' Service Cards, last page.

Why the Taylor TRANSCOPE* controller is ideal for modern processing plants . . .

- *Excellent repeatability*
- *Outstanding adaptability*
- *More accurate response settings*



A WORTHY companion instrument to the revolutionary new TRANSCOPE Plug-in Recorder, the TRANSCOPE Plug-in Controller is especially suited for the short spans of measurement encountered in present-day processing.

1. Repeatability—Not only is the instrument extremely stable mechanically, but under widely varying ambient temperature conditions it still maintains its repeatability. It will also hold its adjustments even when subjected to rough treatment in shipment.

2. Adaptability—As well as providing all response adjustments for immediate requirements, the TRANSCOPE Controller can be quickly and simply adapted to changes in operating conditions or processing requirements, due to skillful design and interchangeability of components.

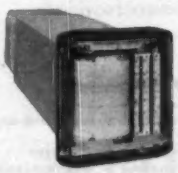
3. Accuracy of Response Settings—Response to adjustments is exceptionally fast . . . a big "plus" on start-ups. Precision manufacture of gain, reset and PRE-ACT* units permits pre-determined mathematical settings.

4. Maintenance is simple because the motion-balance TRANSCOPE Controller is easy to understand, easy to get at. Plug in or plug out in seconds. Rugged bellows assembly, keyed in place, moves the dynamically balanced force plate . . . friction-free bending member never needs maintenance.

Ideally suited for centralized control, and scanning and logging systems. Because of its compactness, responsiveness and simplicity, the TRANSCOPE Controller is a match for your toughest job. Ask your Taylor Field Engineer, or write for **Bulletin 98278.** Taylor Instrument Companies, Rochester, N.Y., or Toronto, Ontario.

*Trade-Mark

THEY BELONG TOGETHER



The Taylor TRANSCOPE Recorder and Controller are companion instruments. Revolutionary accuracy and big instrument features make the TRANSCOPE Recorder the most talked about new instrument in years. *No other recorder, regardless of size, puts so many features in so little panel space.* Write now for **Form No. 98272.**

Taylor Instruments
MEAN
ACCURACY FIRST

VISION · INGENUITY · DEPENDABILITY

IMPORTANT NEWS

Major causes of refinery fouling and corrosion can be eliminated at the crude unit

SEVERE corrosive and fouling agents can now be removed from the crude oil charge before they can do damage. The new CRONOX® C conditioning treatment* rids crude hydrocarbons of dangerous impurities by harmless chemical action. Refineries treating their crude charges with CRONOX C conditioning have greatly extended time on stream and equipment life, while cutting cost and length of turnarounds.

CRONOX C conditioning treatment neutralizes hydrochloric and naphthenic acids, minimizes attack due to highly corrosive organic agents. It scavenges oxygen from the oil, thus retarding attack by hydrogen sulfide and reducing the formation of fouling deposits.

Inject CRONOX C conditioning solution into the crude at the charge pump. Preheat exchangers, crude heaters, crude distillation towers, overhead equipment and bottom exchangers are remarkably free from attack or deposits. The crude unit is safeguarded, and its refined products are less capable of fouling or corroding subsequent equipment.

To learn how you can eliminate major causes of refinery fouling and corrosion easily and economically, ask Aquaness for the new booklet on CRONOX C conditioner. Write today, using the coupon below.

ATLAS

Aquaness *Department*

ATLAS POWDER COMPANY

2005 Quitman Street, Houston 26, Texas

*Patent applied for

Aquaness Department
ATLAS POWDER COMPANY
2005 Quitman Street, Houston 26, Texas

☐ Please send me a copy of the new booklet on Cronox C conditioner.

Name _____

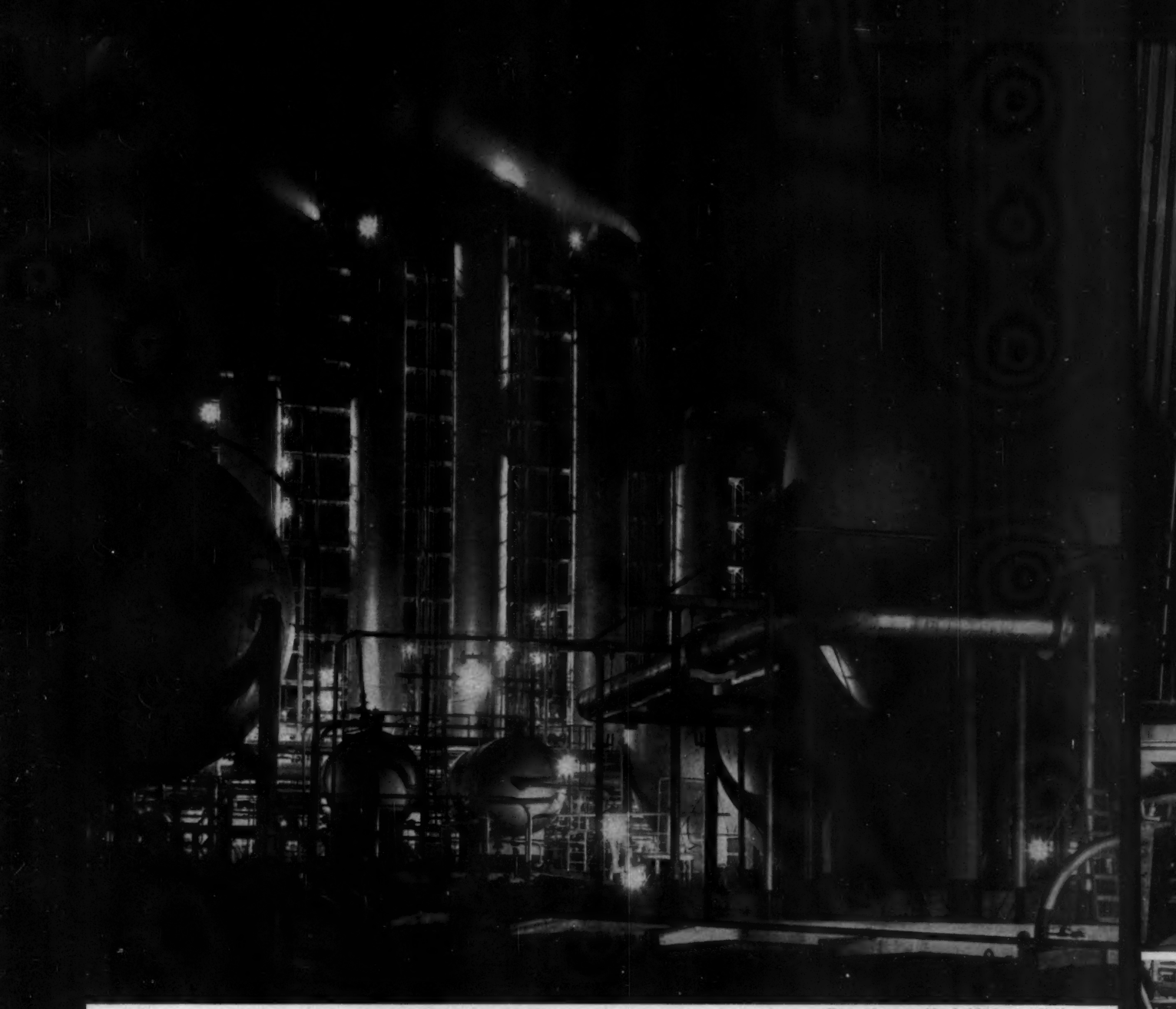
Title _____

Company _____

Street _____

City _____ Zone ____ State _____

For more data on advertised products, use Readers' Service Cards, last page.



—Photograph courtesy of Standard Oil Company (N. J.)

How much can preheat raise throughput?

Today's soaring production costs spotlight the need for increasing throughput . . . that is, if slim profit margins are to be kept from disappearing altogether. A look at the Ljungstrom Air Preheater will show how this can be done.

Ljungstrom efficiency comes from the fact that preheated air mixes more thoroughly with fuel. This assures more complete combustion . . . higher flame temperature . . . and increased heat absorption into the tubes – which raises still throughput by as much as 25%!

For example, an eastern refinery went from 16,000 barrels to 18/20,000 barrels a day when the pipe still was modernized with a Ljungstrom system. In addition, temperature control was much closer. The octane rating of the product, because of this fine control, was held to narrower limits – *with the average rating as much as two octane numbers higher.*

How fast is "WRITE OFF"?

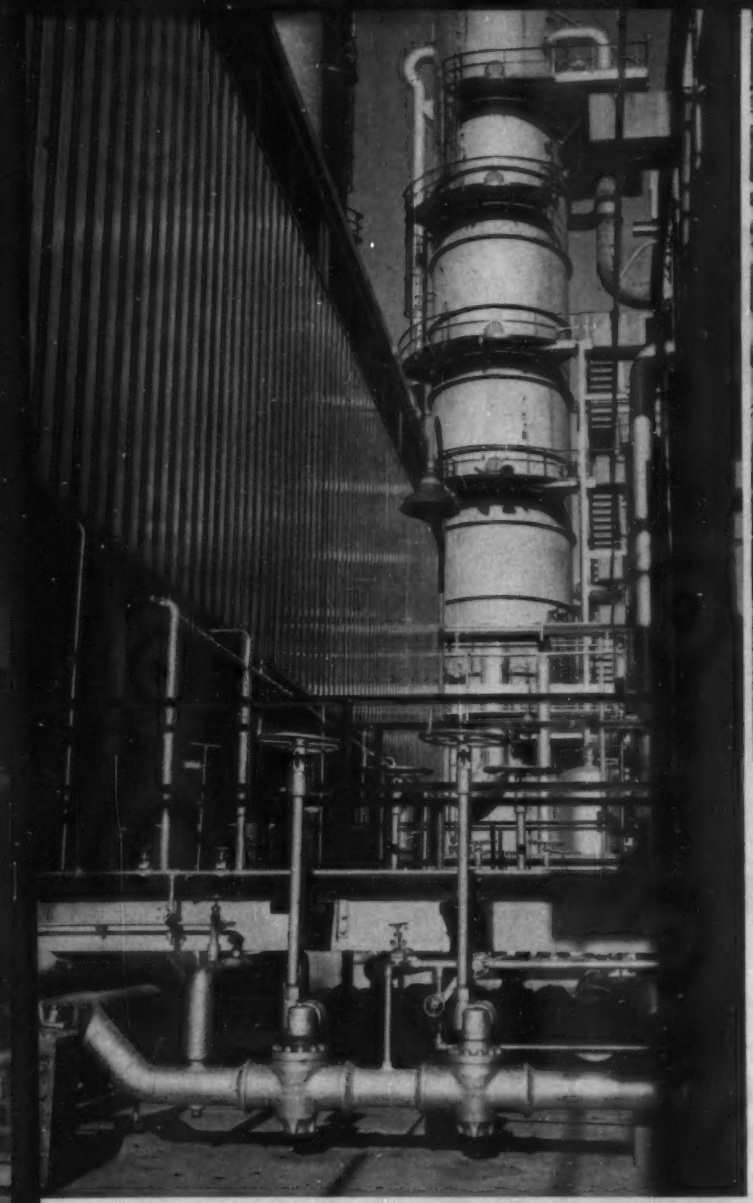
In earnings from increased output and improved quality, many refineries write off the cost of the Ljungstrom in less than 2 years. These costs can be written off sooner, in fact, when you add other Ljungstrom advantages: savings up to 20% in fuel costs . . . higher throughput . . . less slag . . . and use of fuels you used to discard.

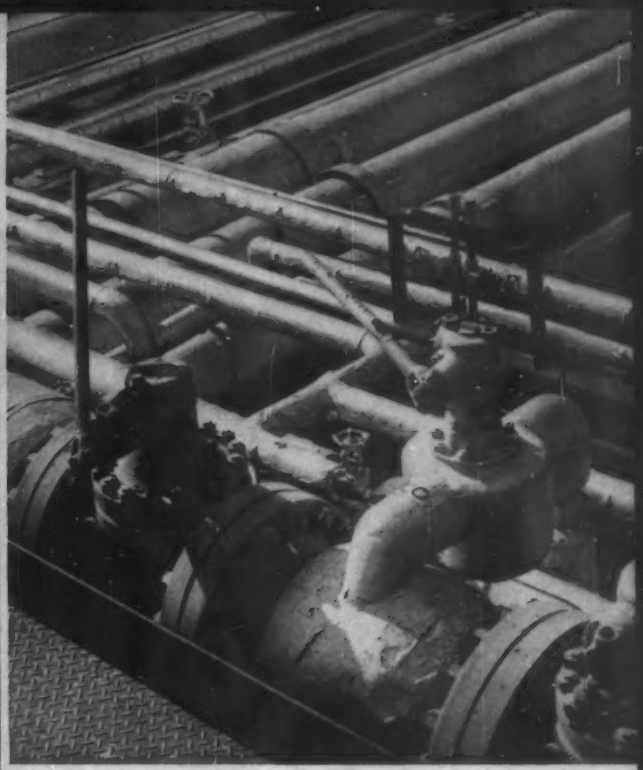
For more complete data on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits obtainable in fuel burning equipment – call or write the Air Preheater Corporation.

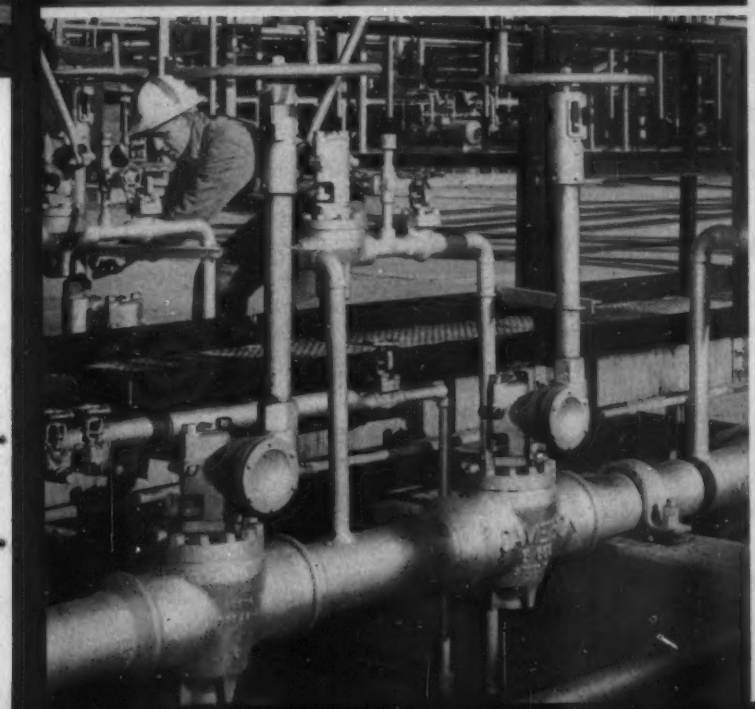
Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.







LIFT-PLUGS
LIFT PROFITS

Because of their unique design, Cameron Non-Lubricated Lift-Plug Valves seal bubble-tight and are exceptionally easy to operate. But these are only two of their advantages. Lift-Plugs lift profits because they require no expensive lubrication program, no special lubricant inventory. This, of course, means no line product contamination and no grease deposits on orifice plates or delicate measuring instruments. They save time and money because they may be welded into the line, eliminating flange costs and the possibility of leaks. When repairs are finally necessary, Lift-Plugs can be made as good as new without removing them from the line. If you are not already enjoying these unusual benefits, call on Cameron to lift profits with Lift-Plugs.

These are Lift-Plug installations at the Delaware Refinery of Tidewater Oil Company.

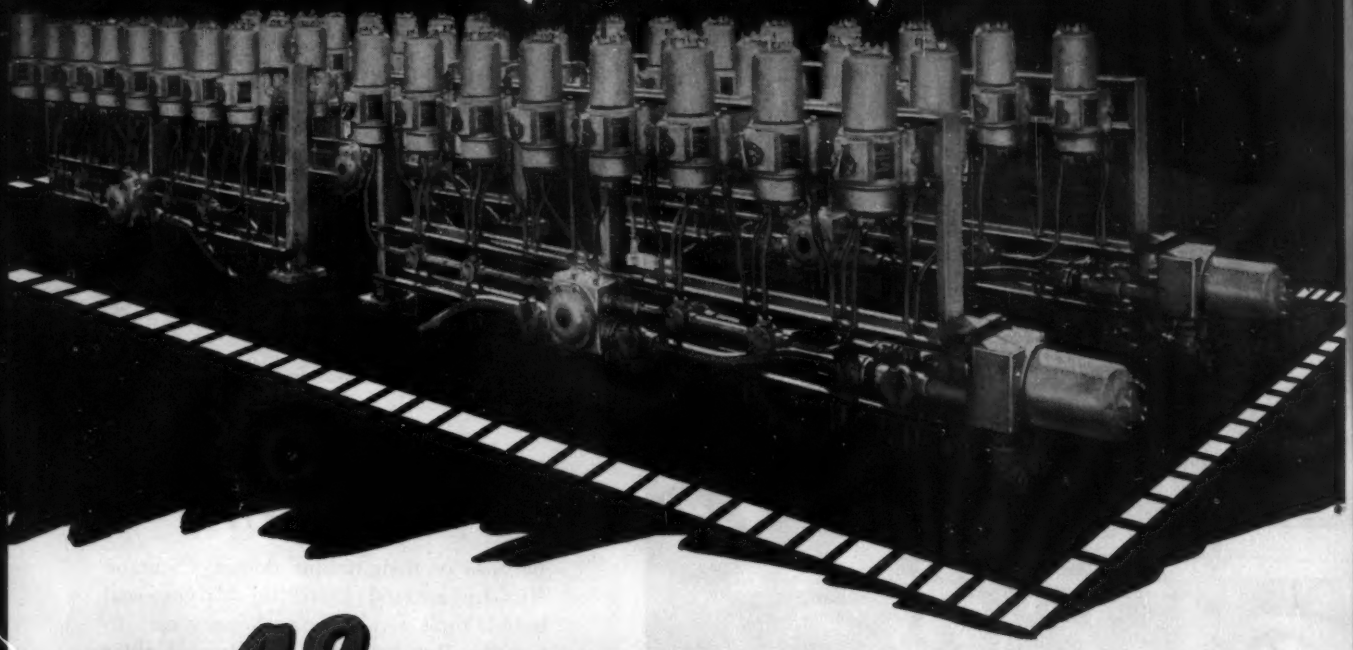
Cameron

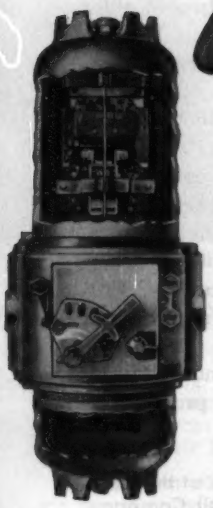
IRON WORKS, INC.

P. O. Box 1212 — Houston, Texas

Export Office: 7912 Empire State Bldg., New York City. In England: Cameron Iron Works Ltd., 76 Grosvenor St., London W. 1 England.

CROUSE-HINDS
Condulet* motor controls
Occupy Less Space!





48 Explosion-Proof Combination Motor Starters and Circuit Breakers . . . *in a 25 ft. x 6 ft. Area!*

Crouse-Hinds Condulet* Type EPC Motor Starters and Circuit Breakers are explosion-proof, dust-tight (dust-ignition-proof) and weather-resistant (raintight).

Lightweight cast aluminum construction for easy installation without use of lifting equipment.

Seven Conduit entrances simplify installation.

Built-in push button stations and selector switches are available.

Starter sizes 0 to 5. Circuit breakers 50 to 600-amp. frame sizes.

In the installation shown above, 48 Crouse-Hinds Condulet* Type EPC combination motor starters and circuit breakers are compactly arranged in four racks.

If necessary, the 25 ft. x 6 ft. area used could have been cut in half by installing the Condulet motor controls in two tiers. Or, *twice* as many Condulet controls could have been installed in the same area, if required.

The *vertical design* of Crouse-Hinds motor starters, circuit breakers and combinations allows them to be installed only ¼" apart. This compactness produces savings in the construction of steel mounting racks, and in the use of premium floor space.

● **For help in solving a space problem, see your Crouse-Hinds distributor . . . or call the nearest Office listed below**

*Registered

A NATIONWIDE DISTRIBUTION exclusively through ELECTRICAL DISTRIBUTORS

CROUSE-HINDS COMPANY

Main Office and Factory: Syracuse, N. Y.

The Mail Box . . .

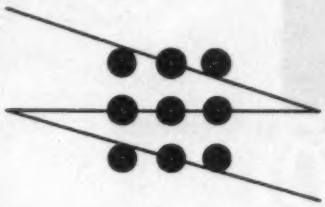
Three, Not Four

To The Editor:

In "The Elusive Art of Thinking" (February, 1958, page 199), breaking a mental block is illustrated with the problem of drawing a given number of straight lines through nine dots. It is shown that, by not restricting the mind, nor the lines, to the area bordered by the dots, the problem can be solved with four straight lines.

Treating the nine dots as dots, not as points, leads to a solution requiring three straight lines. See below:

American Oil Co. Carl B. Lyda
Texas City, Texas



Checking Up

To The Editor:

Re: "The Elusive Art of Thinking."

How could anyone possibly make an erasure with a lead pencil, as such?

F. C. Hardeman

Continental Refinery
Westlake, La.

Editor's Note—Do you mean to intimate that the author AND the editors were not thinking!

What? More!

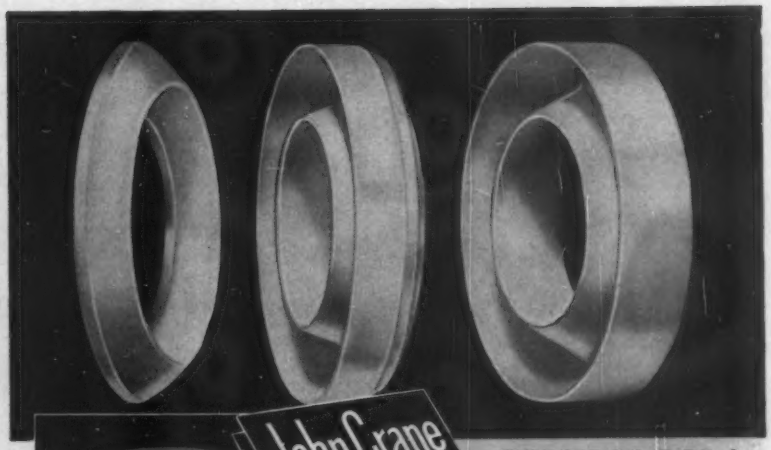
To The Editor:

The problems you presented in "The Elusive Art of Thinking" caused a good deal of favorable comment around our plant. Everybody thoroughly enjoyed them.

In the event you would be interested in more of them, I'm sending you some selections from my collection. They may not be refining but they are fun.

Sweeny, Texas Maxey Brooke

Editor's Note: The 15 brain-teasers Mr. Brooke sent are indeed fun. We'd print them here but think your boss wouldn't think you were thinking while you worked on them.



John Crane

CHEMLON *

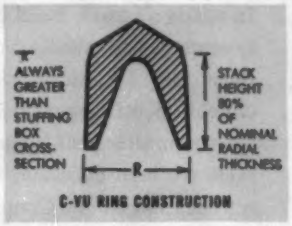
C-V RINGS

ARE INDUSTRY'S MOST UNIVERSAL PACKING . . .

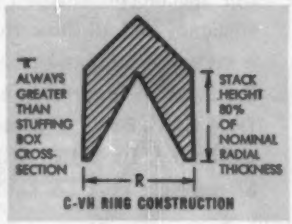
Countless successful applications of C-V Rings under the most severe service conditions have made this the closest approach to a universal packing.

It will effectively handle all industrial acids, alkalis, solvents, organic and hydraulic fluids . . . temperatures from −120°F. to +500°F. . . . is equally suited to valves, pumps, mixers, hydraulic cylinders and like equipment.

"John Crane" C-V Rings have extremely low coefficient of friction. "Breakout" friction is only slightly higher than running friction.



C-VU RING CONSTRUCTION



C-VH RING CONSTRUCTION

TWO STYLES ARE AVAILABLE:

C-VU RINGS *for low pressure service* —such as control and regulator valves handling gases and fluids, where it is necessary to have a very sensitive and resilient type packing.

C-VH RINGS *for high pressure service* —for use in pumps, hydraulic cylinders and like services at pressures ranging to 500 psi. and over. These rings are constructed with a heavy wall heel to withstand pressure requirements. They are designed to provide voids between rings, so that as the Teflon expands due to heat, this take-up room minimizes any excess friction in the stuffing box.

"John Crane" C-V Rings are available in full line of standard sizes and male and female adaptors. Sizes can be molded to stuffing box specifications.

Request Bulletin P-325.

*"John Crane" C-V Rings are made from Chemlon—*the best in DuPont Teflon.*

Crane Packing Co., 6420 Oakton St., Morton Grove, Ill. (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

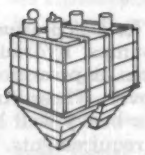
CRANE PACKING COMPANY

Buell Combination Cyclone-Precipitator installation at cement plant.

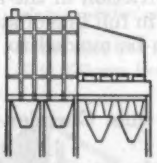
"Paid for itself!"

In nearly all cases, Buell dust or fume collection systems pay for themselves in just a few years. Buell "SF" Electric Precipitators provide extra collection efficiency *and* lower maintenance costs year after year, thanks to features like the exclusive high-emission, self-tensioning Spiral-ectrodes and unique Continuous Cycle Rapping. For specific information about dust collection efficiency and all three Buell systems, write for a copy of the booklet, "The Collection and Recovery of Industrial Dusts." Dept. 21-C, Buell Engineering Company, Inc., 123 William Street, New York 38, N. Y.

BUELL CYCLONE



"SF" ELECTRIC PRECIPITATOR



PRECIPITATOR-CYCLONE COMBINATION

buell®

***Experts at delivering Extra Efficiency in* DUST COLLECTION SYSTEMS**

A Quick Look at the Industry THIS MONTH

Refiners Continuing to Slash Runs . . . In the face of stocks mounting higher and higher, refiners are still cutting back crude runs at plants, many of which are already running at below-capacity levels. Some contend runs will have to be cut by 750,000 bpd to correct the present supply-demand imbalance—others say 400,000 bpd will do the trick.

Oil men are blaming the recession on lagging fuel oil demands, but frankly are at a loss to explain why gasoline consumption has fallen below expectations.

One major announced that although its inventories are at a minimum, industry stocks are so excessive it is more profitable to reduce refinery runs and purchase products currently selling at distress prices.

Only thing which helped alleviate fuel oil stocks was terrific cold wave in Eastern and Midwest portions of country.

Military Avgas Peak Near . . . Last month's report by the Military Petroleum Supply Agency to WPRA members predicted that total military requirements will reach its peak next year. Thereafter, requirements will taper off until 1962, when they become less than six percent of U. S. consumption. At the same time, some avgas requirements will be supplanted by jet fuel (for the complete story, see page 182).

Latest Octane Postings . . . Ethyl survey of major U. S. cities shows premium octane averaged 98.5 for February, up 0.1 from the January average. Also, regular was up 0.1 octane for February average of 91.1.

Recent BuMines report notes average for regular grade last summer of 89.8 was almost four numbers higher than premium average of ten years ago. Survey also said super-grade gasolines during same period averaged 100.9 with some as high as 101.4.

And octanes in the West took a bound as Tidewater announced its premium gasoline is first to have a rating of more than 100.

It Looks Like Tough Sledding . . . for refinery slated in Arizona. Last Fall, Arizona governor was fishing for someone to build a refinery in his state. State board evidently selected the right lure as Bishop Oil and Refining announced plans for a refinery 20 miles west of Phoenix. Strong opposition has developed, however, from Phoenix Chamber of Commerce and merchants who contend smoke and fumes would ruin Phoenix as a resort center.

Another Petrochemical Entry . . . Imperial Oil's new detergent alkylate plant at Sarnia is able to supply Canadian soap manufacturers with all the detergent base they need. With this new plant in production, Imperial has become a petrochemical producer with big plans for the future.

Shale Picture Coming Into Focus . . . Preliminary shale oil economics are now known. Union Oil reports pilot plant costs for retorting have been cut to $1 per barrel. Added to mining costs of $2 per barrel, shale oil can be made available for about $3. But there's still the cost of transporting it to Midwest or Pacific Coast refineries from Colorado.

More shale economics were brought to light by the University of Denver's Research

Institute which said preliminary data indicate the Aspeco retorting costs may be substantially lower than any other retorting process known.

Meanwhile, Navy is still hoping to get the green light from the Justice Department to lease oil shale facilities at Rifle, Colo. Once go-ahead is received, Navy will issue invitations for bids from interested parties. Lease will include entire facility, housing, plant and mine.

Latest Trends in Refinery Maintenance . . . Virtually all maintenance authorities agree that lower maintenance costs are tied to good housekeeping. With economic pressure by refinery management to reduce maintenance costs, look for an increasing trend to better housekeeping in refineries and petrochemical plants.

Along these same lines, a great many small and medium plants have never before used a maintenance budget—but they're learning it's necessary in times of economic slumps.

Another trend to watch is the increasing use of contract labor when shortage of specialists—such as boilermakers and painters—exists. Though such a tendency is increasing, don't look for any wholesale shift to contract maintenance.

Fuel Injection A Bust? . . . Detroit may have been pinning hopes on fuel injection as a fuel economy measure, but recent Ethyl research claims fuel injection will give added octane but won't increase miles per gallon.

Actually, fuel injection appears to be heading for the scrap-pile. Chrysler has dropped it; American Motors has announced but hasn't produced; and total output of Pontiac and Chevrolet has only been about 3,100 units.

More Cracked Stock in Diesel . . . You can look for more cracked distillates for high-speed diesel engines. Distillates are making high quality diesel fuel but additives are required in some cases.

A Quick Look Around the Country . . . General Motors is testing an automatic highway guidance. Cable under road sets up magnetic field to steer car without driver putting a finger on the steering wheel . . . **at least one company** is considering building an offshore gasoline plant . . . **Ingram Oil & Refining is putting** its 18,000-bpd New Orleans plant back on stream. Plant has been shut down for several months as a result of fire . . . **Pontiac Western has completed arrangements** for acquisition of Wilshire Oil Co. and Wilshire Products. Wilshire owns and operates 50,000-bpd refinery at Norwalk, Calif.

The Natural Gas Bill—A Political Football? . . . Late last month one national newspaper chain headlined the rumor that the firing of Bernard Schwartz as chief counsel of the House Commerce Committee was connected with a political "deal" involving the natural gas bill. The "deal": House Republicans would deliver enough GOP votes to insure passage of the gas bill providing Democrats agreed to soft-pedal any probe of the regulatory agencies which might embarrass Eisenhower's administration.

Renewed efforts of coal industry to tack-on coal interest admendments to the bill; complete distortion of the "Porter letter"; and claims by Sen. Wiley (R.-Wis.) that passage of the bill would result in increased rates of $500 million annually, all combined to paint a pretty gloomy picture for the future of the natural gas bill.

But even after all this furor there is still one bright spot on an otherwise dark horizon. That is President Eisenhower's word at a press conference that he has not changed his mind as to need of legislation for exempting natural gas producers from utility-type controls.

ABOSITE...

THE NEW INSULATION FOR VESSELS

ABOSITE IS RUGGED. Drop it . . . Walk on it . . . ABOSITE will take it—without breaking, chipping or cracking.

ABOSITE HAS "BUILT-IN" EXPANSION JOINTS. Hard on two main surfaces, Abosite is "cushioning" and resilient inside. The vessel expands—bands tighten—Abosite spreads—joint cracks fill. RESULTS: No Double Layer, Joint Filler, Longitudinal Expansion Joints.

ABOSITE IS EFFICIENT . . . Where it counts! What other insulation has a "K" of only .62 @ 1000° F.? At 200° F., "K" factor is .38. Such efficiency means thickness savings. Thickness savings mean dollar savings.

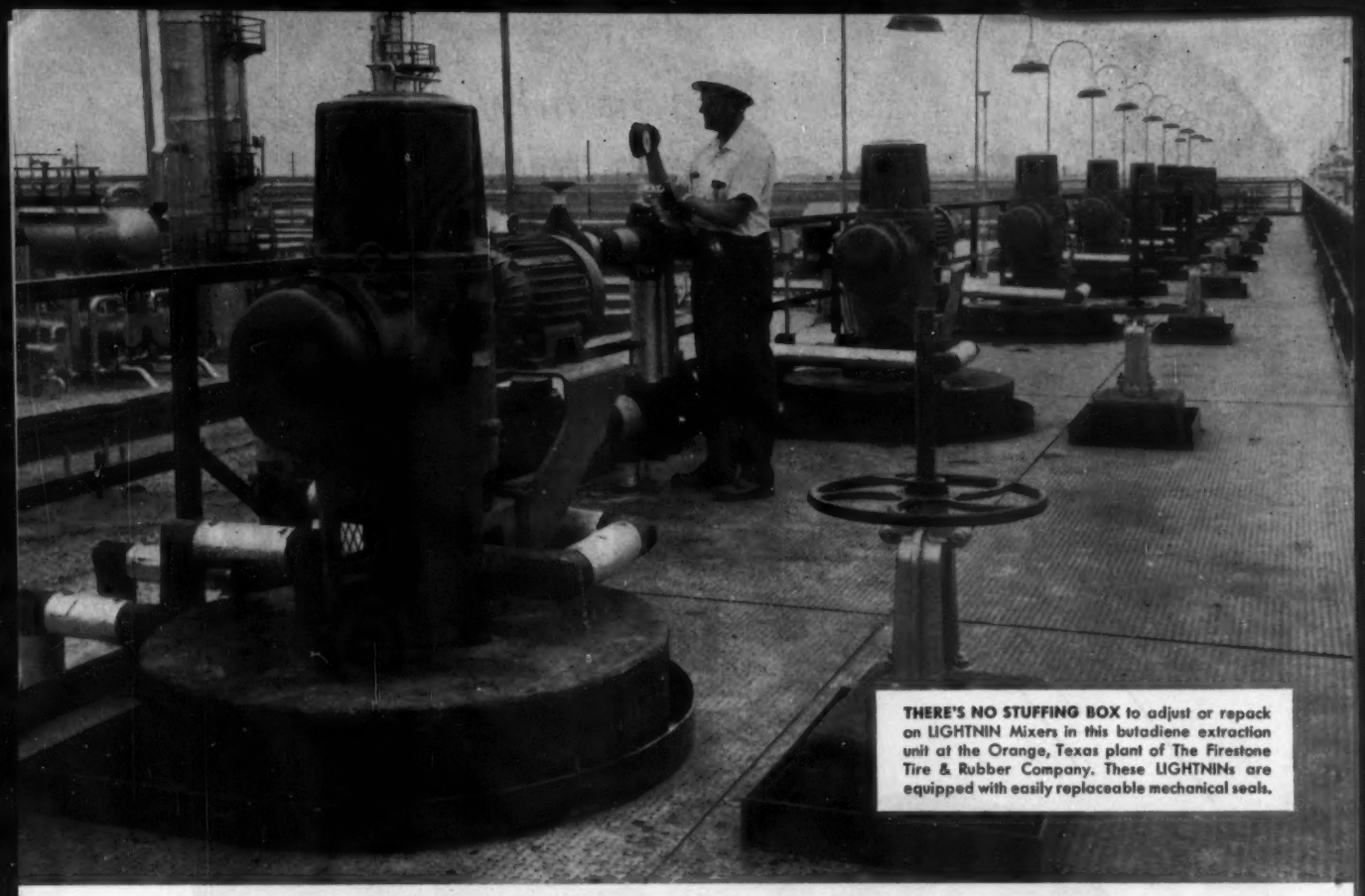
ABOSITE HAS WIDE SIZE AVAILABILITY. Fabricated from master billets, Abosite is available to 36"x48"; thicknesses through 4", and prebeveled lags to fit vessel O.D.

THE ABER COMPANY, INC.

4832 Almeda Rd. • P. O. Box 2535 • Houston 1, Texas

BRANCHES: BATON ROUGE • SHREVEPORT • PORT ARTHUR

For more data on advertised products, use Readers' Service Cards, last page.



THERE'S NO STUFFING BOX to adjust or repack on LIGHTNIN Mixers in this butadiene extraction unit at the Orange, Texas plant of The Firestone Tire & Rubber Company. These LIGHTNINs are equipped with easily replaceable mechanical seals.

How to keep a solvent extraction train highballing

A crucial problem facing the engineers who designed this butadiene solvent-extraction train was: how to *keep* it continuous.

In these nine tanks, mechanical mixers were needed to provide intimate contact between the solvent phase and the hydrocarbon phase for quick and complete recovery of butadiene.

But where was a proved mixer design that would keep running for years—without frequent short stoppages for repacking, or costly dismantling in case of a shaft seal failure?

They found the answer in the LIGHTNIN Mixers you see here.

These LIGHTNINs never have to be repacked. Each is equipped with a *mechanical shaft seal that positively prevents leakage*—and runs, not for months, but for *years* without ever needing adjustment.

New shaft seal—in a hurry

Best of all, seal replacement is a fast, simple job.

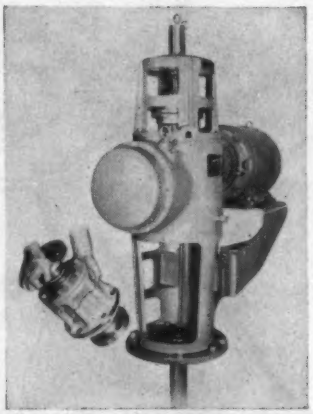
When a seal eventually does wear out, it can be replaced quickly. There's no need to dismantle the mixer or take it off the tank. No need for highly trained personnel, either; any man who can handle a wrench can replace the LIGHTNIN seal.

He merely unbolts two couplings; takes out the seal cartridge as one piece; couples in a new cartridge. Mixer shaft alignment is built-in—need not be checked.

If you're mixing corrosive chemicals under pressure or vacuum, you may save many thousands of maintenance dollars by specifying Series "E" LIGHTNIN Mixers with these quick-change mechanical seals.

You can get LIGHTNINs in hundreds of power-speed combinations, for tanks of any size or shape. Performance is unconditionally guaranteed.

For the full story on increased productivity you get and long-term maintenance savings you make with seal-equipped LIGHTNIN Mixers, call in your LIGHTNIN representative. He's listed in Refinery Catalog. Or write us direct.



CARTRIDGE SEAL runs for years without adjustment . . . and uncouples for rapid replacement.

☐ *Quick! Send us the cost-cutting facts on LIGHTNIN Rotary Mechanical Seals—Bulletin B-111. We'd also like catalog information on these LIGHTNIN Mixers:*

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering propeller type: ¼ to 3 HP (B-103)
- ☐ Side entering; 1 to 25 HP (B-104)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Data sheet for figuring mixer requirements (B-107)

Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT CO., Inc., 164-c Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 10, Ont.

Lightnin® Mixers™

MIXCO fluid mixing specialists

A Case of Effective Teamwork

THE OIL INDUSTRY and United States' military force have an unusually long and noteworthy record of effective work as a team. The U. S. defense and, in time of war, its striking force have been immeasurably strengthened as a result.

At the recent joint meeting of the WPRA and the Military Petroleum Supply Agency in Houston, Chairman Donald C. O'Hara took a few moments to remind us of this unusually long and close relationship.

It was early in this century when the great navies of the world changed over from coal to oil, and at that time countries were far-sighted enough to recognize that no nation could hope to be a sea power in the future unless it was sure of an adequate supply of oil.

In order to provide for the security of the American Navy, the government established the Naval Petroleum Reserves. These reserves reached their peak of production during World War II, but still they provided less than two-tenths of one percent of America's daily production of crude. Aside from this reserve, the government has depended entirely on private enterprise to provide the production, refining, storage and transportation of oil necessary to meet Armed Force demands.

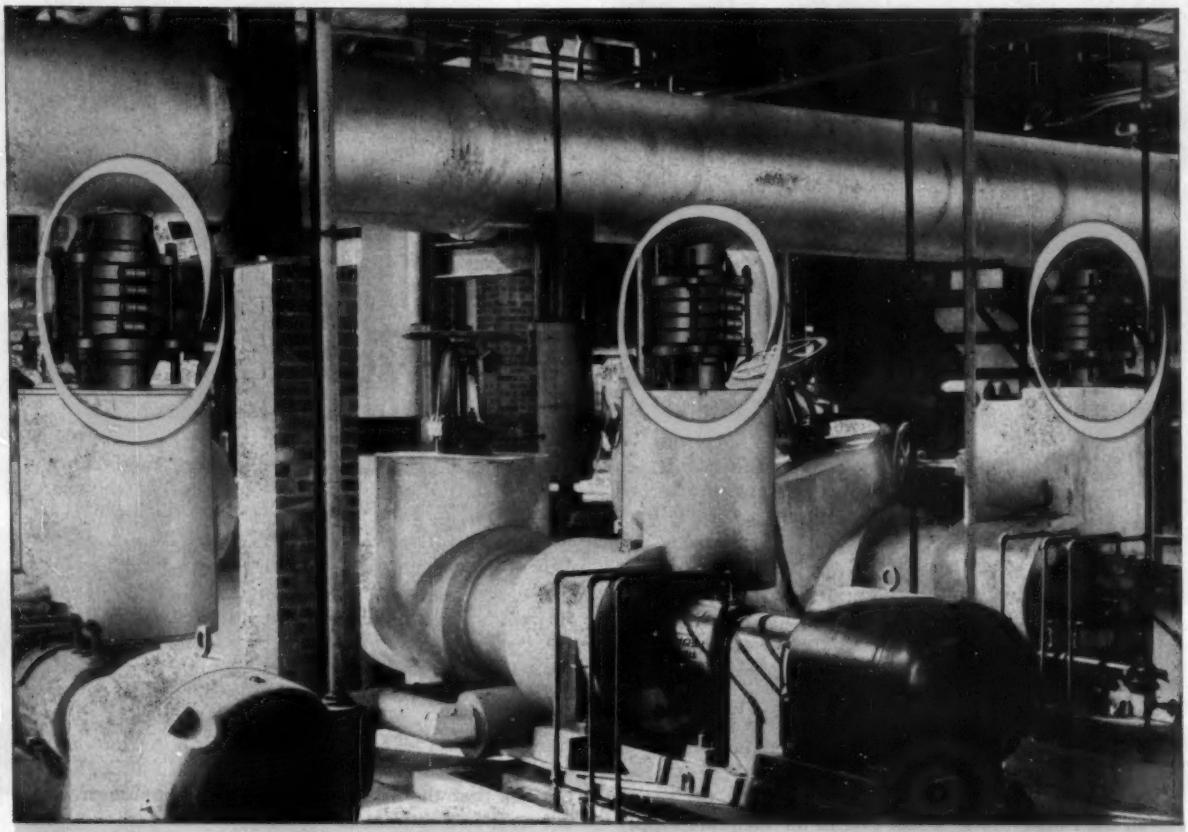
A Constant Factor. Over the years, O'Hara reminded, the needs have changed greatly, and the Air Force has supplanted the Navy as the greatest user of petroleum products. One thing which has remained constant however, is the teamwork between the oil industry and the military. We cannot help but wonder if some of the facts of what oil does for this country aren't forgotten or over-looked by industry critics when they raise their voices again and again in condemnation. Let's take for example, the system of military supply. When a man at an Army post needs a new pair of boots, he can get them from his supply room. But how did the supply room get them? Well, they were shipped from the manufacturer to a central depot on a government bill of lading. That was the last the manufacturer ever saw of them. From that time forward, they moved through military channels, and the costs of transportation and storage, the risks of loss in transit or deterioration, the risks of obsolescence, or a reduction in the quantity needed were all borne by the military. This same holds true with a case of tomatoes, ammunition, typewriters, radios, and practically all other items of military supply.

Petroleum, however, is an entirely different story. When a post supply officer needs gasoline for his motor pool, he does not call a military supply depot, he calls an oil company—the one that currently holds the contract to supply the post with gasoline. This means that no matter where the gasoline was refined, it travelled all the way from the well to the Army post through the oil company supply system. The company paid all the costs of transportation and storage, took all the risks of loss or deterioration, and the risk that the base might not want as much product as it had estimated.

How many people do you think are aware that 21 of the largest air bases in the country are now supplied with jet fuel and aviation gasoline by pipe lines laid into the base? In nearly every case, these lines were built by a private company, at its own expense, with no guarantee of a contract to supply product or even that the requirements at the base would continue. These lines are operated as common carriers.

A Saving, Too. Perhaps the American citizen is not aware of how much of his tax money is being saved through the use of these pipe lines. The Department of Defense is aware of it, however, and recently commented that, "The efficiency and the economy of pipe line delivery for volume fuels were readily apparent. This type of delivery has been effected at two of our bases with a reduction of transportation costs of about $500,000 annually . . . The fuel requirements of Strategic Air Command could not have been met without pipe line delivery. This mode of delivery has resulted in a 75-percent reduction in personnel required by SAC to receive the fuel, a 90-percent reduction in the number of receiving documents, a 75 percent reduction in the time required for fuel receipt and no transit loss of fuel because delivery was to a destination contract."

The military has been able to take advantage of intergrated competitive supply systems which were originally set up by private oil companies to better serve the people of the United States. Even so, we still hear cries in Congress for bills, which if passed, would throw the whole refining and marketing end of the oil industry into chaos. Take for example, bill



ADSCO CORRUFLEX EXPANSION JOINTS SOLVED A PIPING PROBLEM FOR NATIONAL ANILINE

The new $20,000,000 diisocyanates plant of the National Aniline Division, Allied Chemical & Dye Corp., at Moundsville, W. Va., is known for many engineering wonders, especially its miles of intricate piping. The photo above shows three ADSCO Corruflex anti-compression packless expansion joints used to secure satisfactory piping connections between the main piping and three pumps.

If rigid piping had been used to connect the three pumps to the 18-inch main feeder, the piping soon would have been twisted and overstressed by the growth of the main feeder when hot process liquid was pumped through it. National Aniline engineers, in consultation with ADSCO engineers, decided to use the anti-compression joints shown in the photo. These are deflected laterally with minimum strain on the connecting piping and pumps as the main feeder expands or contracts. Also, the joints absorb vibration of the pumps and motors.

For efficient, right-working pipe line arrangements, use ADSCO Corruflex expansion joints. Packless, they require no maintenance. Sizes, 3" to 54"; for temperatures to 1600 F and pressures to 300 psi.

REMEMBER! Use ADSCO Expansion Joints instead of Pipe Bends because of these advantages:

1. Less Heat Loss **2. Less Pressure Drop** **3. Less Space** **4. Less Cost**

ADSCO DIVISION
20 MILBURN STREET
BUFFALO 12, NEW YORK

YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.

H.R. 426 which would make it a crime for any producing or refining company to retail petroleum products. We wonder if its legislative proponents have taken into consideration that a law of this type would deprive suppliers of an assured outlet for their products and the retailer of a constant supply? The practice of scheduled refinery runs and product deliveries would be completely upset, and there would be glutted markets in some areas and acute shortages in others. The time and money saving coordination which is second nature in a single organization would be lost and the overall price of petroleum products would no doubt be much higher.

Certainly the Armed Forces appear well satisfied with the way things are now. The Military Supply Agency for whom O'Hara was speaking knows that only with petroleum where there are intergrated, private supply systems, can they count on a dependable delivered supply of products which meet specifications at competitive prices.

All Americans, whether they know it or not, are reaping the same benefits.

Unforgettable Kalichevsky

V. A. KALICHEVSKY, consulting chemical engineer for Magnolia Petroleum Company, looked forward to retirement in three years. He was to join the faculty of the Lamar State College of Technology then and was already serving as a special lecturer at Lamar.

Behind him stretched an oil publication career that numbered more than 80 articles (27 in PETROLEUM REFINER) and five books. But this effort was only a small part of his contribution to petroleum literature. For it was "Kali" who inspired, counseled and worked with numerous associates on manuscripts that were eventually published without his name attached.

V. A. Kalichevsky

Born in Russia, "Kali" was graduated from the War College there. When his six-year military and diplomatic career in Europe and the Far East was ended by the Red revolution, he came to the U. S. to get his B.S. degree in chemical engineering from Cal Tech. That was when his oil career started with Union Oil of California and took him through positions with Standard Oil Development Company, Socony-Vacuum Oil Company and finally to Magnolia in 1944.

Several processes for refining gasoline, kerosine and lubricating oils were conceived by him or developed under his supervision.

On February 4, 1958, Kali died in Beaumont.

R&D—How Many Know?

AMERICA'S RESEARCH and development program—its springboard to scientific supremacy—is for the first time, the most important single operation in this country. It is being microscopically disected and examined piece by piece in an effort to determine how it can be improved.

At the same time, we are reviewing the methods used by R&D people to inform government leaders of new developments, and how they should be utilized. In short, America is looking at its system of communications.

Following this same line of thinking, perhaps it would behoove many oil-industry firms to slip their own R&D departments under the microscope to look at what kind of a "product" this multimillion dollar a year effort is producing. And whether or not company communications are well enough organized so that top management is kept abreast of R&D activities.

Perhaps all too often, the sole connection between top management and the research and development department is the lonely R&D report. With all due respect for this report and its originator, it often leaves a great deal to be desired. Many times it is not an accurate analysis of the work which has been done, but is rather, a recitation of the steps taken and the difficulties encountered in accomplishing an objective. How much better it would be for those reading the report, if it would indicate the status of the work, its potential commercial value to either the company or its customers, and recommendations or conclusions that would serve as a guide to management.

Another phase of this whole question of communications is the employment of that system which requires estimates of R&D activity be delivered orally as well as written. The oral report affords not only the opportunity of more personal contact between the research lab and the front office, but also sets the stage for a question and answer period which gives both sides a chance to clarify vague issues. It does not matter what form this session takes, the important point to remember is that meetings of this sort go a long way in improving communications.

Research and development is the heart of progress, and even though it's a multimillion dollar operation, we should take care not to waste a penny of it.

We stand today at the gateway of what promises to be a great scientific revolution which will probably work a far greater change in our mode of living than the so-called industrial revolution has wrought in the past century or so. Most of us cannot even imagine the wonderful new devices and appliances that will become common-place necessities of our daily life in the next few decades . . . And all of this—experience has shown—will mean more jobs, more purchasing power, more leisure, and a more comfortable life for our people.

—BENJAMIN F. FAIRLESS
United States Steel Corporation

Measuring gas temperatures in an engine combustion chamber by radar. This technique depends upon the relationship between the velocity of sound in a gas and the temperature of the gas.

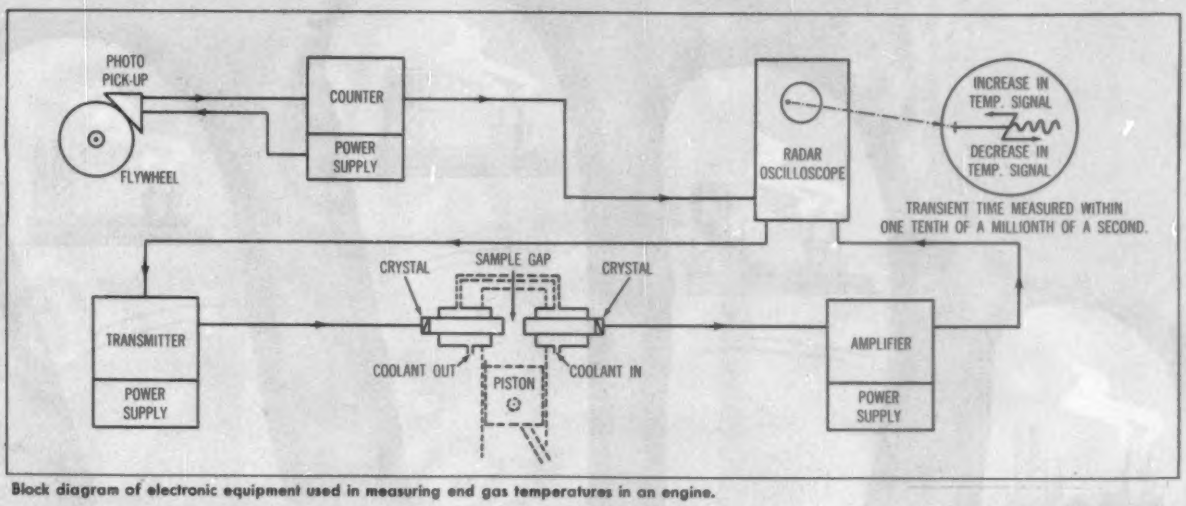
Ethyl Research Uses New Technique to Measure Combustion Temperatures

"Nearly all the grandest discoveries of science have been but the rewards of accurate measurements..."

—Sir William Thomson (Lord Kelvin), 1824-1907

Inability to measure the temperatures of the burning gases in an automotive engine has long impeded understanding of combustion phenomena.

Such measurements are a problem primarily because they involve time durations as short as millionths of a second. Even the most sensitive temperature-sensing devices generally are too slow for such work.



Block diagram of electronic equipment used in measuring end gas temperatures in an engine.

Method Developed at Massachusetts Institute of Technology

Recently, scientists at the Massachusetts Institute of Technology, in a research program supported by the Coordinating Research Council and the Office of Ordnance Research, developed an ingenious solution to the problem.

The solution of the M.I.T. scientists is based on the classical thermodynamic relationship between the velocity of sound in a gas, the properties of the gas, and its temperature.

Calculations Check With Latest Theories

Ethyl Research, the first industrial laboratory to adopt this new method of temperature measurement, has found that the technique yields highly reproducible results.

Ethyl scientists also have determined that temperatures indirectly measured by the velocity of sound method check closely with calculations based on the latest theoretical concepts.

The mathematical expression of the relationship between temperature and the velocity of sound in a perfect gas is the equation

$$V^2 = \frac{Cp/CvRT}{M}$$

where **M** = molecular weight of the gas
Cv = specific heat of the gas at constant volume
Cp = specific heat at constant pressure
R = universal gas constant
V = velocity of sound in the gas at the absolute temperature, **T**

Since present knowledge of combustion provides answers for the specific heats and the molecular weight, measurement of the velocity of sound permits calculation of the gas temperature.

Radar Measures Sound Velocity

The M.I.T. method that was adopted by Ethyl Research people is to send a precise sound pulse—a 2,000,000-cycle-per-second vibration—from one side of the engine's combustion chamber to the other.

Then a radar oscilloscope and associated electronic equipment measure accurately the amount of time taken by the sound to cross the chamber.

Additional electronic equipment triggers the sound at any given instant in the engine cycle, thus permitting temperatures to be calculated throughout the cycle.

This new research tool opens the way to important new discoveries in the field of basic combustion. It also should prove valuable in furthering our knowledge of the mechanism of knock and antiknock action.

How Ethyl Research is helping you

By keeping constantly alert to new techniques and advances in scientific knowledge, Ethyl Research people supplement their own technology to expand the ever-widening knowledge of fuels, engines, and combustion.

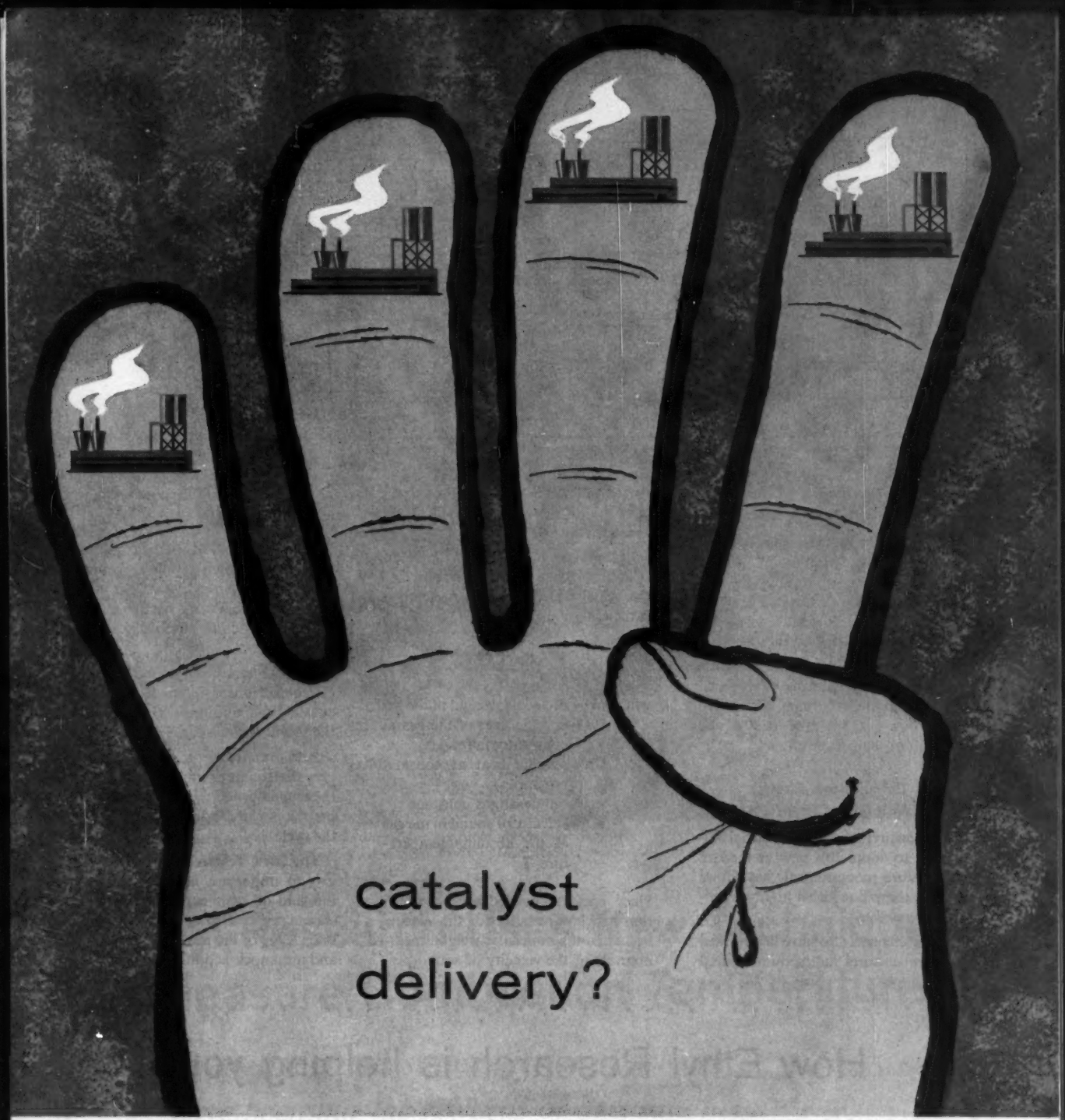
Ethyl Technical Representatives are available at all times to give your technical people access to the great store of information developed in years of specialized fuel-engine research.

For further information, just call your Ethyl Representative. He will welcome the opportunity to arrange an appointment for you with one of our Technical Representatives.

ETHYL CORPORATION
New York 17, N. Y.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

RESEARCH LABORATORIES:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.



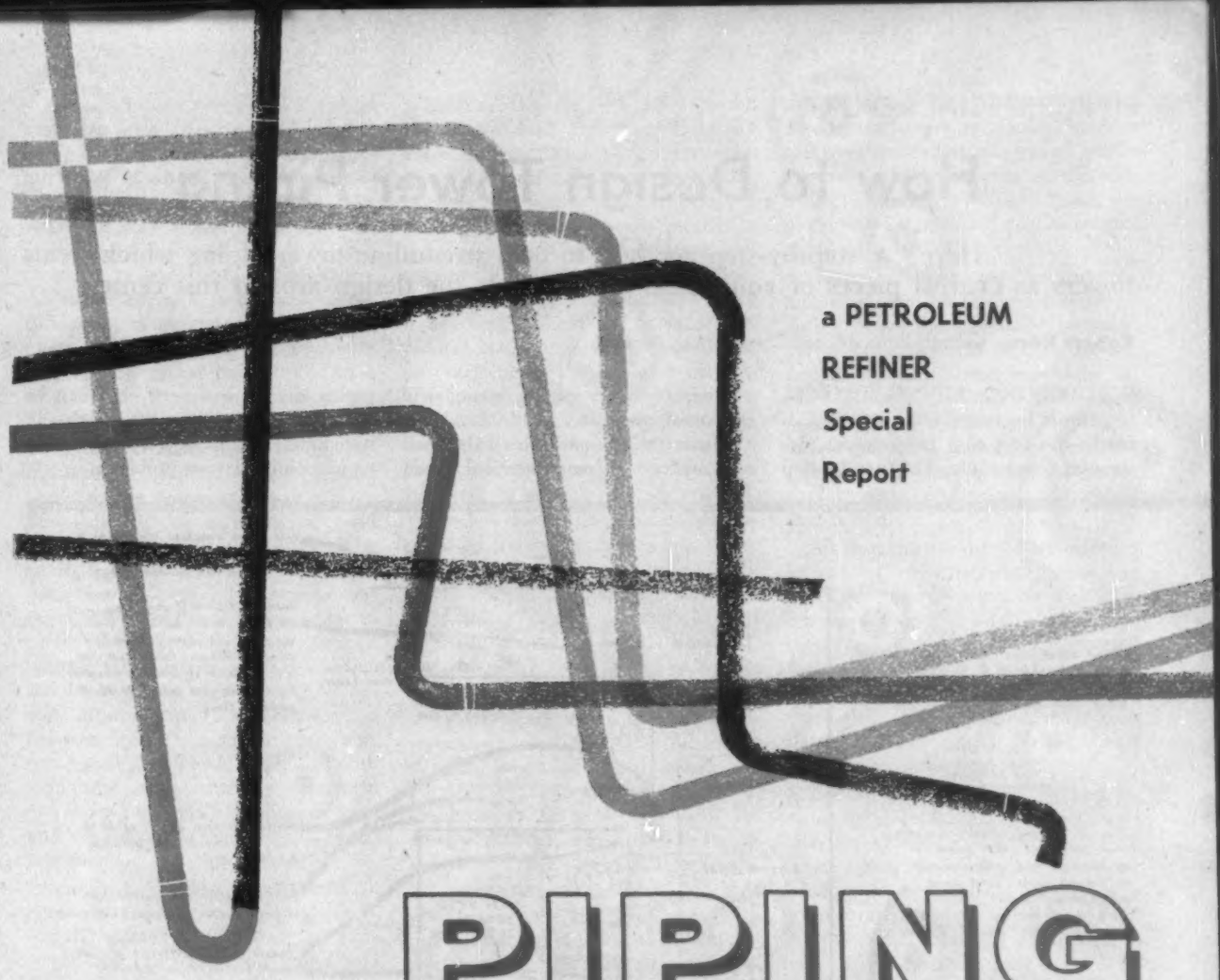
Davison catalyst plants are located in Baltimore, Md.; Cincinnati, Ohio; Lake Charles, La.; affiliated plant in Valleyfield, Quebec.

Four—count 'em—four catalyst plants back up Davison's claim of quick service

Fact: Davison has more plants producing petroleum catalyst than any other manufacturer. Fact: There is a Davison plant within easy shipping distance of most of the nation's refineries. Fact: Each plant is on main transportation arteries so shipments can be made by rail, truck, ship or barge. Conclusion: Davison delivers catalyst where—and *when*—you want it.

DAVISON
CHEMICAL COMPANY
Division of W. R. Grace & Co.
Baltimore 3, Maryland

Buy DAVISON—the quality catalyst backed up by experience, research, technical assistance, service!



a PETROLEUM
REFINER
Special
Report

PIPING

Why a Special Report on Piping? Because piping is one of the major cost items in all process plants. Piping materials and labor represent so many dollars in plant costs, it deserves some special treatment.

Once the flow diagram is made, actual piping is left to the designers. Here's where the actual piping money will be spent. By applying engineering at this stage, not only will the designer do a better job, but the project will be less costly.

Yes, this Special Report can help you do your job better. Tower Piping Design by Robert Kern (Page 136) is a step-by-step method to streamline tower piping design.

Neither the cheapest nor the strongest piping material is necessarily the most economical for any piping system. Dan Christopher's method (Page 143) gives the most economical piping material for any temperature and pressure.

How to estimate pipe fabrication and erection labor is shown by O. R. Roberts (Page 147).

Stanley H. Fistedis (Page 150) presents a pipe support foundation design method which simplifies this routine task.

The high-pressure piping design check list by E. E. Ludwig (Page 155) is a must for your design notebook.

PETROLEUM REFINER'S Special Report thus runs the gamut of piping design—from high pressure to fabrication labor to support foundations. Keep in mind that piping may amount to more than 25 percent of total project cost. It's really big business.

How to Design Tower Piping

Here's a step-by-step method to help streamline tower piping which treats towers as central pieces of equipment and extends the design around this center.

Robert Kern, Kellogg International Corporation, London

TOWERING PIPING DESIGN, sometimes neglected but always a factor in the cost of a process unit, deserves a closer study. This step-by-step analysis of tower piping layout will save manpower and material.

Much has been written on the various aspects of petrochemical plant piping design, but very little can be found on the analytical approach and systematic design development of a typical piping layout problem.

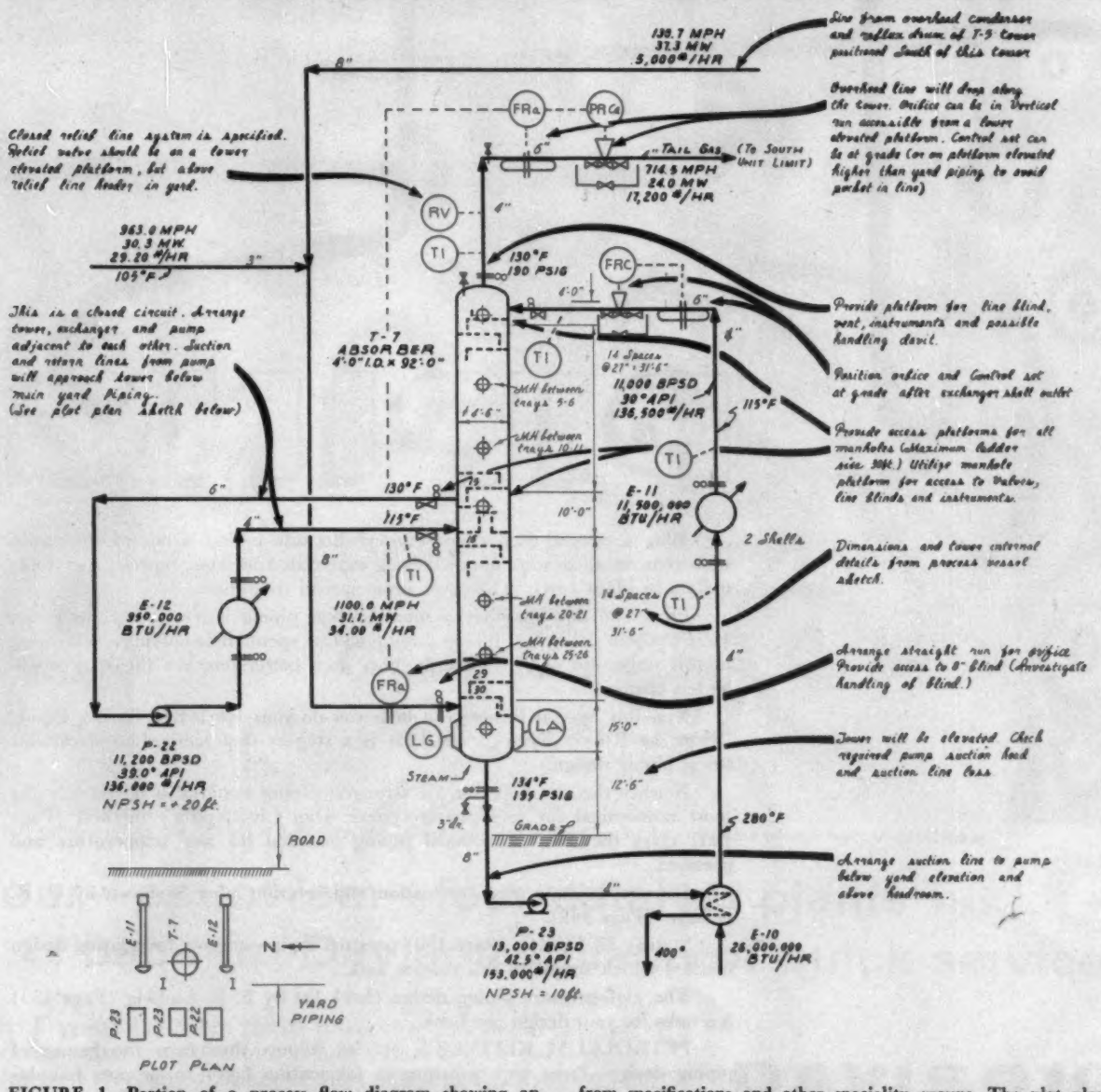

Line from overhead condenser and reflux drum of T-7 tower positioned South of this tower
139.7 MPH
37.3 MW
5,000 #/HR
Overhead line will drop along the tower. Orifice can be in Vertical run accessible from a lower elevated platform. Control set can be at grade (or on platform elevated higher than yard piping, to avoid pocket in line)
Closed relief line system is specified. Relief valve should be on a lower elevated platform, but above relief line header in yard.
"TAIL GAS" (To South Unit Limit)
714.5 MPH
24.0 MW
17,200 #/HR
963.0 MPH
30.3 MW
29.20 #/HR
105°F
130°F
190 PSIG
This is a closed circuit. Arrange tower, exchanger and pump adjacent to each other. Suction and return lines from pump will approach tower below main yard piping. (See plot plan sketch below)
T-7
ABSORBER
4'-0" I.D. x 92'-0"
Provide platform for line blind, vent, instruments and possible handling davit.
14 Spaces @ 27" = 31'-6"
11,000 BPSD
30° API
136,500 #/HR
115°F
Position orifice and Control set at grade after exchanger shell outlet
MH between trays 5-6
MH between trays 10-11
Provide access platforms for all manholes (Maximum ladder size 30ft.) Utilize manhole platform for access to Valves, line blinds and instruments.
130°F
115°F
E-11
11,900,000
BTU/HR
2 Shells
Dimensions and tower internal details from process vessel sketch.
E-12
950,000
BTU/HR
1100.0 MPH
31.1 MW
34.00 #/HR
MH between trays 20-21
MH between trays 25-26
14 Spaces @ 27"
31'-6"
Arrange straight run for orifice Provide access to 8" Blind (Investigate handling of blind.)
P-22
11,200 BPSD
39.0° API
136,000 #/HR
NPSH = 20 ft.
Tower will be elevated Check required pump suction head and suction line loss
STEAM
134°F
195 PSIG
GRADE
280°F
ROAD
Arrange suction line to pump below yard elevation and above headroom.
P-23
13,000 BPSD
42.5° API
153,000 #/HR
NPSH = 10 ft.
E-10
28,000,000
BTU/HR
400°
E-11
T-7
E-12
N
YARD PIPING
P-23
P-23
P-22
PLOT PLAN

FIGURE 1—Portion of a process flow diagram showing an absorber tower and adjacent equipment. Items shown in color interest the layout engineer and can be calculated or collected from specifications and other speciality groups. The plot plan in the lower left corner gives the general arrangement. Notes around sketch give step-by-step evaluation by layout engineer.

A considerable portion of material cost goes into piping and related equipment. Consequently, an important share of capital expenditures depends on the piping designer. His work not only affects initial material cost, but the subsequent cost of construction, operation and maintenance. All this of course is in addition to the fulfillment of engineering requirements, equipment accessibility, safe and reliable operation, effectiveness of control and easy maintenance.

Simplicity Is Economy. The requirements of good piping layout in general apply to the design of tower piping. Simplicity is the hallmark of good piping design. Pipe lines should be routed as directly as possible, with a minimum of loops, pockets and crossovers. Manifolds should be similar to each other in design and grouped symmetrically where possible. Use should be made of standardized details, grouping and minimum spacing between lines. Pipes should preferably run parallel with each other and with structures and equipment. Uniform elevations for horizontal banks of yard and equipment piping should be established.

Simplicity is closely connected to economy. Piping cost depends on size, length, material (carbon or alloy steel) and the number of valves and fittings used in each system. The layout engineer should minimize the pipe length and number of fittings. The shortest lines and the least number of fittings will obviously provide the most economical piping arrangement. The cost factor represented by pipe and valve sizes is the flow system engineer's responsibility. Nevertheless, the piping designer can often improve an uneconomical system. Valves can sometimes be eliminated and line sizes decreased with a well engineered physical layout. Short lines and simple piping arrangements, by minimizing pressure drops, lower pumping costs.

During design, constant cost comparison between alternative solutions, even if only quick mental approximations, is the concern of the cost-conscious designer.

Detailed Requirements. For valves and blinds the best location is directly at the tower nozzles. Valves in branch connections or at nozzles should be in a position where the line will be self-draining on both sides of the valve. A "dead leg" over a closed valve collects liquid or solids. The trapped liquid can freeze, or, when opening the valve without draining the leg, can upset process conditions.

Locally mounted temperature and pressure indicators in process lines should be visible from the line valve handwheel, so that the operator can observe the changes while manipulating the valve. Temperature connections on towers are usually located in the liquid seal of the tray downcomers. In front of thermowell nozzles a clearance of approximately 2 feet is required to remove the thermowell.

Pressure connections are usually located in the vapor space, just below the trays. Pressure and temperature connections located between trays and high above tower platforms should be accessible and, if locally mounted, the indicator's face should be visible from the ladder.

Tower piping often lends itself to vertical orifice runs. The necessary straight length of pipe before and after orifice flanges must be provided. Permanent access or provision for portable ladder access should be allowed for orfice flanges and tappings.

Orifice flanges can be arranged in vertical or horizontal pipe runs, with due consideration given to the flowing medium and the direction of flow. For clean liquids, dry gas or air, the location of orfice flanges can be in either horizontal (preferred) or vertical pipe runs. In the latter case, the flow can be upward or downward. For steam lines, wet gas or wet air, the orifice can be in either horizontal or vertical (preferred) with the measured medium flowing downward. For liquid-vapor mixtures horizontal or vertical upflow is recommended.

In case of manually controlled streams, flow meters should be visible from the control valve. For flow meters in air and gas service the transmitter should be placed above the orifice. This permits self drainage of any moisture back into the line. A drain pot is required if the transmitter is below the line. For liquid lines, transmitters and controllers may be below the orifice. Orifice tappings in horizontal air or gas lines are usually in the top; for liquid lines the tappings are usually horizontal. Pressure and temperature in the line should be measured on the same side of orifice.

The transmitter of a level controller should be accessible for adjustment. The control valve set should be near the level controller; and gauge glasses (covering the level range of the controller) should be visible from the globe valve handwheel in the control valve set by-pass.

Generally, indicating-type instruments in control services should be visible from the manually operated valve. In automatic control service, pneumatic transmitters should be located close to the orifice or pressure point. This is even more important in viscous fluid service, in order to reduce time delay in the instrument circuit between sensing, responding and action.

All instruments should be oriented so as not to obstruct the passageway at ladder exits or entrances. Convenient access and grouping of instruments and valves will help inspection and plant operation. Instruments should not be located adjacent to manholes. The manhole cover can damage instruments when being swung open during maintenance.

Besides the cost of piping and instrument installation other cost factors are also related to piping layout. The piping designer influences the amount of steel needed to support a group of pipes or individual lines. Valve and instrument arrangements can affect platform and ladder requirements. Poor nozzle orientation can require a greater area of tower platform than might otherwise be necessary.

Finally the piping designer can reduce the operators' and maintenance men's work by providing easy, safe and adequate access and removal space for valves, instruments, manhole covers and internals.

While aiming at an ideal and economical piping, fitting and instrument arrangement, the designer must sometimes accept engineering limitations. Occasionally, mechanical and physical requirements will affect and can add to the cost of piping installation and related structures. Hot lines often cannot be routed as directly as cold ones. Smaller lines have to give preference to large lines thus assuming a less than optimum route. A remote line may require a longer route in order to run where supporting steel can be arranged more readily. Tower nozzles, because of internal restrictions, cannot always be oriented to suit a convenient external piping arrangement. Fre-

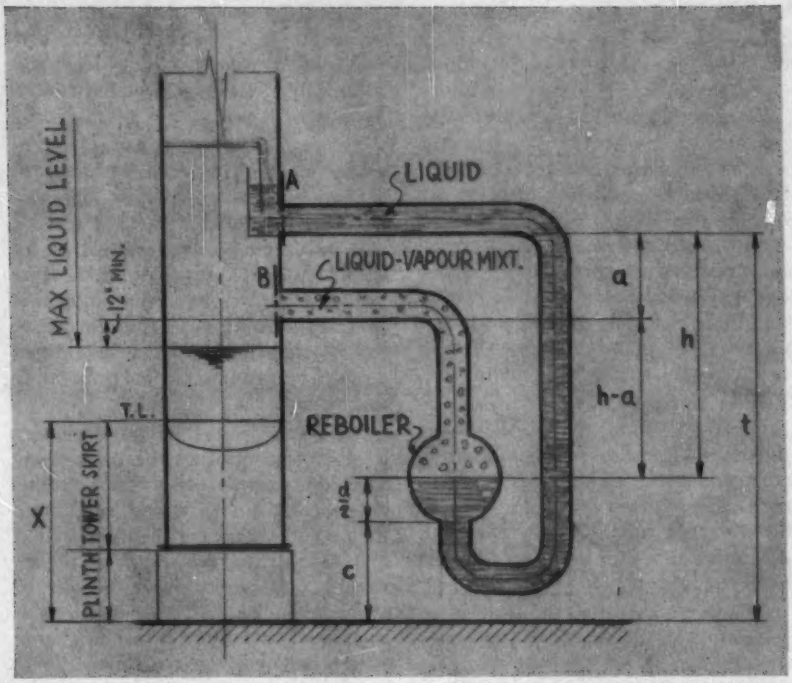


FIGURE 2—Method of calculating tower skirt height when a thermo-syphon reboiler is envolved.

quently segments of circular platforms or ladder extensions have to be added for access to instruments.

Information Required. Before tower piping can be designed, some essential information has to be supplied to the layout engineer. This information in order of importance is as follows:

1. Specifications, describing among other things, minimum access, walkways, platform widths and headroom requirements; handling facilities for tower internals, manhole covers, line blinds and relief valves; maximum rise of ladders; piping system requirements—open or closed relief lines, minimum line sizes, etc. Specifications should also give special plant requirements, local regulations, reference to codes and safety practices.

2. Flow diagrams. Figure 1 shows a portion of a process flow diagram for an absorber tower and adjacent equipment. Marked on it in color are those details which interest the layout engineer and can be calculated or collected from specifications and from other specialists carrying out the design of the plant.

Final flow diagram information will, of course, appear on the mechanical flow diagrams, which show the complete piping systems and details, as well as the instrumentation.

Specifications and process flow diagrams are sufficient for the initial design. At this stage plant layout and design ideas are produced. Figure 1 shows how a process flow diagram is evaluated. It shows how to make the first steps toward the development of a physical tower arrangement. To complete the layout in detail the designer needs:

3. Plot plan giving the physical location of the tower and its relationship to other equipment, main access, main pipe runs and pumps.

4. A preliminary drawing of the tower giving the size, details of internals and positions of process connections.

5. Instrument sketches or instrument standards, showing the location of instrument connections to the tower for gauges, level controllers, level alarms, pressure and temperature connections.

6. Pump net positive suction head requirements or reboiler data to establish the elevation of the tower above grade.

7. Physical details of instruments, equipment and pipe accessories in the form of manufacturer's catalogs or standard drawings.

8. Line and equipment insulation details.

An integrated layout must be developed from this information. The customer's requirements written in the specifications have to be remembered and applied. The designed unit should be a functional part of the plant, properly laid out with respect to related equipment and facilities as shown on the plot plan. Vessel drawings, instrument sketches, pump or reboiler data, and dimensioned equipment sketches will govern the external arrangement of tower piping.

What Elevates the Tower. Tower elevation, (dimension X on Figure 2) is governed by five factors.

1. Net positive suction head requirements if the tower bottom line is a pump suction line. This can elevate the tower bottom tangent line from 5 to 20 feet. Pump NPSH (specified by the pump manufacturer) plus the head of suction line loss equals minimum tower elevation.

2. Thermo-syphon type reboiler circuits can also elevate a tower. The driving force in reboiler circuits is the static head difference between the head (Figure 2 dimension h) of the liquid drawoff line, and that of the liquid-vapor mixture in the return line (dimension h-a). Consequently, including frictional losses in the system,

$$h = \frac{144 \times \Delta p \cdot f - \rho(h \cdot a) \cdot a}{\rho h - \rho(h - a)} \text{ ft.}$$

$\rho_{(a-a)}$ = density in the return line inch lbs./ft. 3

ρ_h = density in the drawoff line.

Δp = pressure drop between points A and B in lbs./sq.in.

f = safety factor (usually f = 3)

Dimensions 'a' and 'c' are usually about 3 feet; 'h' is usually 8 to 10 feet. Increasing h can mean a decrease in reboiler circuit line size and increase in tower skirt height. Practical velocities and pressure drops of course limit the minimum line size. By recreasing h the liquid head driving force is decreased; consequently the line size of the thermo-syphon circuit will have to be increased to provide lower friction loss in the system. This can mean a lower tower

skirt, but increased line size, thermal forces and flexibility problems in the hot reboiler lines.

Symmetrical piping arrangement between the tower drawoff and reboiler inlet nozzles; similarly between the reboiler outlet and return connection on the tower is preferred for equal flow in reboiler circuit. But non-symmetrical arrangements are also accepted for a more economical or more flexible piping design. A reboiler is, in most cases, located adjacent to its tower.

3. Gravity flow from the tower bottom or from an elevated nozzle can also elevate the tower. Line sizes and arrangement of piping in the gravity flow system, diameter of the liquid collecting drum, clearances for valves on the drum bottom can influence the elevation of the tower.

Headroom requirements, the use of a common platform for two or more towers, or the elevation chosen for the main yard piping might warrant a further adjustment of tower elevation and warrant a recheck of altered conditions in the pump suction line or reboiler lines.

Special plant design requirements can also elevate towers. The arrangement of process equipment and towers on a concrete table top with the pumps placed below is an example.

4. The requirement of accurate liquid flow in control in tower bottom outlet, with liquid near the boiling point often results in elevating the tower. (See Figure 3). In such cases a static head is required in the front of the orifice to overcome flushing in the line. Flushing liquid through an orifice results in inaccurate metering and, consequently, upsets control conditions.

5. Finally the tower can be at minimum elevation if flow conditions permit it. Practical skirt heights vary from 3 to 6 feet for towers 2 to 15 feet diameter, with bottom temperature 100 to 400 F. Higher temperatures can add 1 or 2 feet to these heights to avoid the transmission of unduly high temperatures to the concrete tower foundation or supporting steel structure. Tower temperatures below freezing point also warrant investigation and will elevate the tower higher than the practical minimum.

These five points affect tower heights, and thus the cost of elevating the tower. To support the tower at

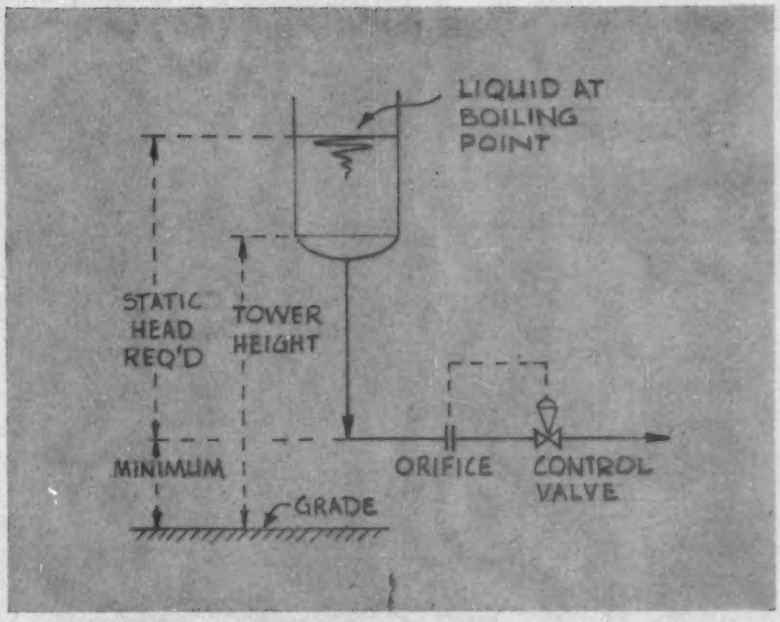


FIGURE 3—Here's how liquid level control can elevate a tower.

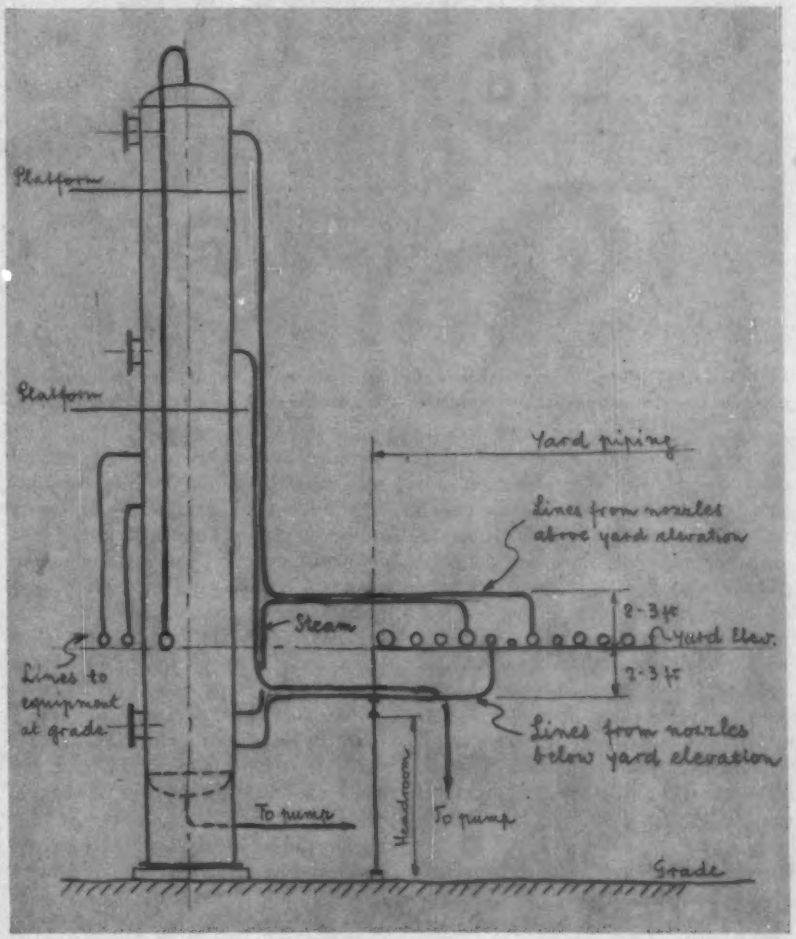


FIGURE 4—Sketch of tower elevation showing how manholes, tower platforms and yard piping affect tower piping design.

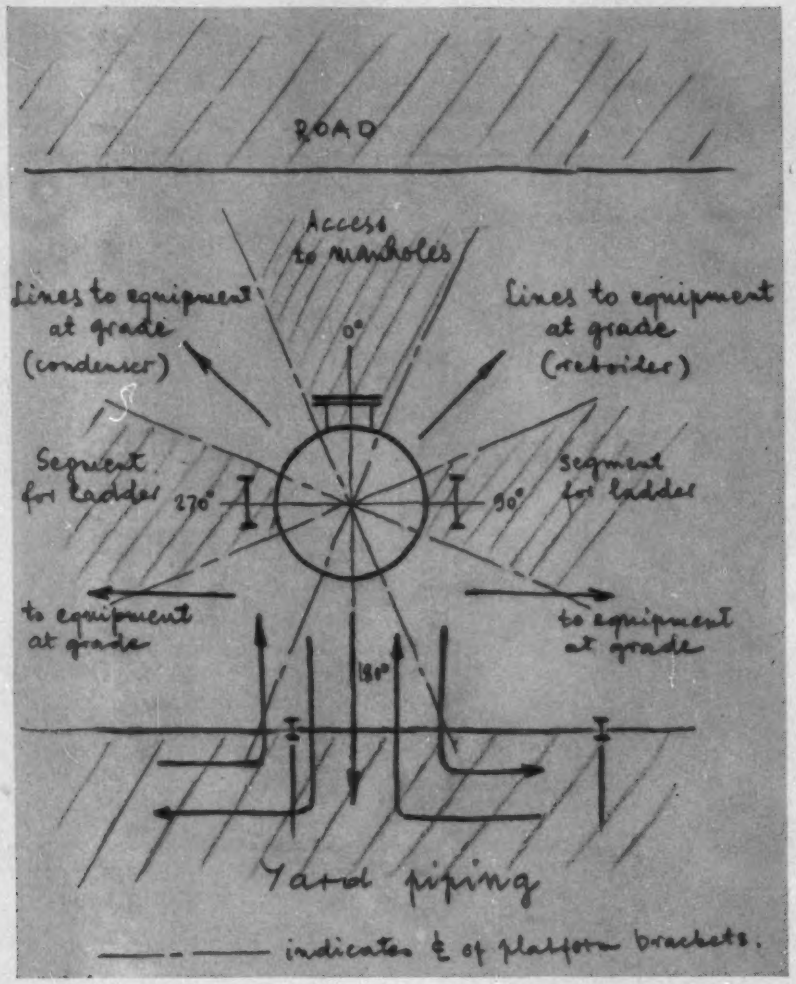


FIGURE 5—Tower plan sketch showing segments allotted to piping, nozzles, manholes, platform brackets and ladders, in a pattern which usually leads to a well designed layout.

the chosen elevation, a steel skirt down to grade or a combination of a short steel skirt and a concrete plinth will be required. It is difficult to decide between steel skirt and concrete plinth. The cost is affected by local conditions, type of soil and foundation. Long skirts can affect skirt and shell thicknesses of a tower, wind load moments and skirt interior access. Slender towers often have flared skirts etc. Cost comparison between alternatives, if possible and if data is available, decides the most economical solution.

How to Analyze Tower Piping. Figure 4 shows a tower schematically in elevation, with its principal features: manholes, tower platforms and pipe runs. Nozzle elevations are determined by process requirements and manhole elevations by maintenance requirements. For economy and easy support, piping should drop or rise immediately upon leaving the nozzle and run parallel and as close as possible to the tower itself. The horizontal elevations after the lines leave their vertical run is governed by the main yard piping elevations. Lines which run to equipment at grade, more or less in the direction of the main yard pipe bank, often have the same elevation as the yard piping.

Reboiler line elevations are determined by the drawoff and return nozzles, and orientation is influenced by flexibility considerations. Lines from tower nozzles elevated below the yard should approach the yard 2 or 3 feet below the yard elevation. The same elevation is used for those lines which run to pumps or equipment located below the yard. Pump suction lines are usually arranged on this elevation. They should be as short as possible and run without loops or pockets. Pipe lines dropping from above the yard elevation will approach the yard on a level 2 or 3 feet higher than the main yard elevation. This elevation is also used for steam, exhaust steam and condensate lines. These lines usually connect to the top of their respective headers to avoid excessive drainage toward process equipment.

Figure 5 shows a tower in plan with segments of its circumference allotted to piping, nozzles, manholes, platform brackets and ladders, in a pattern which usually leads to a well-designed layout. The complete circumference of the tower is theoretically available to arrange these items.

The first and easiest step is to orient the manholes, preferably all in the same direction, which helps the piping layout. The removal and lowering to grade of tower internals will be made more convenient if manholes face the main access way. The lined-up manholes will occupy a segment of the total 360° of tower circumference, which space should not be occupied by any pipe runs.

From a layout standpoint it is preferable to have equal platform bracket spacing and the orientation of brackets lined up along the whole length of the tower. This will minimize interferences between piping and structural members. Ladder arrangements to platforms require more thought. Some specifications permit the use of a single flight while others limit the length of ladder.

Tower piping, valves and instrument accessibility influence the position of ladders. In Figure 5 the segments at 90° and 270° have been initially chosen for ladder locations interconnecting the required tower platforms. This again restricts two segments of the tower circumference from pipe line location.

In routing pipe lines the problem is to interconnect tower nozzles with other remote points. The tentative orientation of a given tower nozzle is on the line between the tower center and the point to which the line is supposed to run. Segments for piping going to equipment at grade are available between the ladders and

both sides of the manholes. Lines approaching the yard can turn left or right depending on the overall arrangement of the plant. Respective segments for these lines are between the ladders and 180°. The segment at 180° is convenient for lines without valves or instruments, because this is the point farthest from manhole platforms. Obviously, the sequence of lines round the tower is influenced by conditions at grade and careful consideration will pay off as design progresses.

The right relationship between process nozzles and tower internals is very important. One angle is usually chosen between the radial center line of internals and tower shell center lines. By choosing the proper angle many hours of work and much annoyance can be saved. Tower piping, the simplicity of internal piping and manhole access into the tower are affected by this selection. Consequently, the tower piping designer must know the details of tower internals. Then the information produced by the designer boils down to the right orientation of tower nozzles. This will automatically contribute to a good piping arrangement.

Layout analysis should be started from the top of the colum, but with the designer visualising the layout as a whole. There will be no trouble in dropping the large lines (such as the overhead vapor line) straight down the side of the column. The lower spaces can then be laid out with piping and nozzles knowing what space is already occupied by these large vertical lines. If the design is started at the base of the column there will be revisions later when the large pipe lines are routed at the upper levels.

Condensers are often located at grade. In such cases the large overhead line drops right alongside the tower to the condenser at grade. Condensers can also be elevated (in vacuum service, or where close control must be obtained in the tower, or for any other process reason). An elevated condenser is more convenient from a tower piping layout standpoint because the large overhead line leaves the immediate vicinity of the tower at a high level, leaving the lower section open, say, for a ladder from grade to the first platform.

Whether the condenser is at grade or at an elevated level, the flexibility and thermal load problems connected

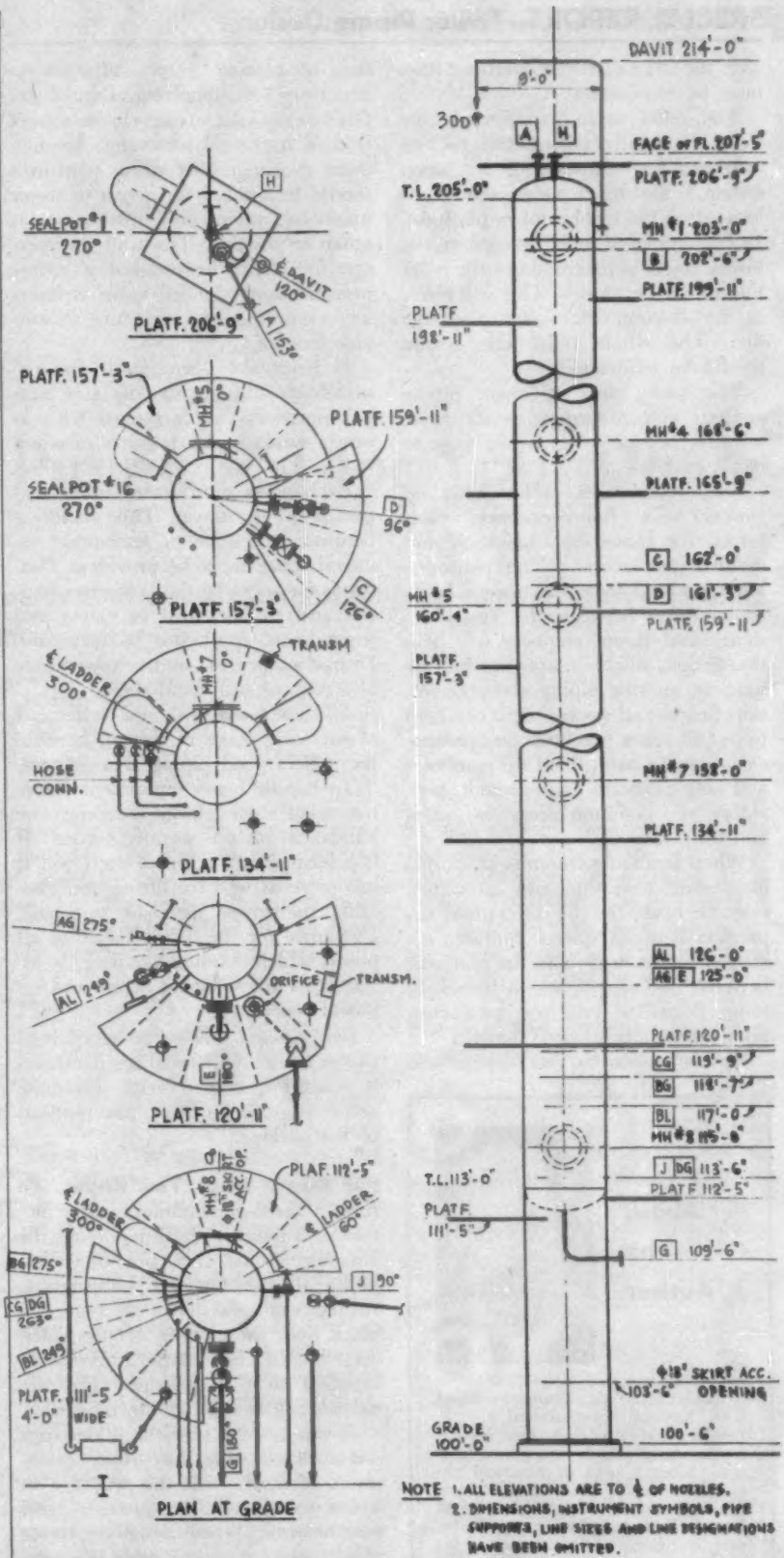


FIGURE 6—Here's how you form a three-dimensional mental picture of a tower with all its details. The black lines are copies from information supplied by others and the colored lines show the designers actual work.

with the large diameter overhead lines must be considered.

The relief valve protecting the tower is usually connected to the overhead line. In case of an "open system," the relief valve should be located on the highest tower platform. In case of closed relief line system the lowest tower platform above the relief line should be chosen. This will result in the shortest relief valve discharge line. The whole relief line system should be selfdraining.

The basic ideas of tower piping analysis and procedure is the same whether one or more towers have to be arranged.

Some companies prefer lined up towers with interconnecting platforms, for convenient operation and maintenance access. The platforms are supported from the towers. Early co-operation between the vessel designer and layout engineer will help the design. Slight alterations in tray spacing, internal piping arrangement, skirt height and tower length can help to put all tower manholes on the same elevation. In turn, lined up manholes will help platform arrangement, providing also common access to valves and instruments.

When arranging common platforms for several towers in line, allowance must be made for the differential expansion between towers. Suitably arranged hinges or slots in the platform between two towers, which introduce some flexibility into the platforms, are a commonly adopted design.

Another common arrangement is that of placing towers adjacent to structures for supporting elevated exchangers and drums; or towers framed into steel structures. In such cases exchangers or drum platforms should be utilized for access to tower manholes, valves and instruments as much as possible. The wall thickness can sometimes be reduced if a low pressure, long slender tower is laterally supported in a structure at suitable heights.

It helps the operators if valving, manifolds and instruments (for similar purposes) are arranged with as much similarity as possible on each tower.

Exchangers are sometimes supported on the tower. Tube handling facilities and tube or exchanger removal space must be provided. Platforms for access to the exchanger bonnet and channel and to valves and instruments, must also be furnished. Drums supported on the tower may also require additional access.

All these features should be decided at an early stage of design, because they affect good piping arrangement.

To handle heavy equipment (large size relief valves, large diameter line blinds) a davit is usually needed. If it is located at the top of the tower it can serve as well for lifting and lowering the tower internals to grade. Clearance for the lifting tackle to all points which require handling, is essential as are sufficient access and removal space.

For packed towers a permanent trolley beam over the filling manholes is usually provided with adequate access at grade for lifting and removal of the packing.

Put Down What You Know. To form a three-dimensional mental picture of a tower with all its details the designer should first put down on paper all the available information. In the example shown in Figure 6 black lines show those details which are virtually copied from information supplied to the designer. The designer's actual work is shown in color.

It can be seen that the main work is connected with the proper orientation of nozzles and the provision of access to points of operation and maintenance. When designing tower piping keep in mind what happens to a line when it leaves the limits of the designer's part of the plant. Tower piping can influence the layout of the piping in adjacent areas, and is itself influenced by adjacent piping as well.

Generally, manhole platforms should be utilized for operating and maintenance access as much as possible without crowding valves and instruments.

In the example of Figure 6 three 30° segments of tower platforms serves the manholes. A break in the ladder rise usually means an additional segment (see el. 112′-5″ and 165′-9″). Small valves are arranged outside the platforms (el.112′-5″) and large ones over the platforms (el. 165′-9″) for safe and easy access. Manhole platforms are utilized for service hose connections.

Some organizations insist on having gage glasses over platforms (see el. 111′-5″) but others will accept access to these from ladders. Additional platform access has to be provided to valves located opposite the manhole (see el. 111′-5″ and 206′-9″).

At elevation 120′-11″ valves, the relief valve, orifice plates and the transmitter of a level controller are accessible. On the top of tower at elevation 206′-9″, a platform is provided for a handling davit, for access to the line blind and the vent valve.

Despite these provisions, the tower and design is not yet finished. The vessel expert has to check the correctness of the layout engineer's work as it affects the tower, and later design the tower in all its details. Line expansion and pipe loads which affect the tower shell and the structural design must be investigated. Support clips, special pipe supports, and any other necessary details must be added. The structural expert has to design platforming and foundation details.

The colored part of Figure 6 shows the limits of the designer's responsibilities concerning tower piping design. For efficient work the piping designer should establish a proper sequence of design development and dovetail the various specialty groups.

A tower is usually a major part of a designer's area. It is advisable to treat it as a central piece of equipment and extend the design round this center. Co-ordination within one are is as important as co-ordination between adjacent plant areas; and also among the various experts of plant design.

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About the Author

Robert Kern is a planning engineer with Kellogg International Corp., London, where he does plant layout, piping design, and design coordination. After a year of practical engineering work, Kern studied mechanical engineering at the Royal Joseph Technical University, Budapest, Hungary, where he received his engineering diploma in 1946. He left Hungary in 1948 and went to England where he joined Kellogg.

More Piping PSI for Your Dollar

Here is a unique method of quickly determining the most economical piping material for any pressure and temperature.

Dan Christopher
Gray Tool Company
Houston

SELECTING a piping material that will most economically meet a desired specification is a problem best solved by a team.

- Engineers to check the material specifications.
- Purchasing agents to check the material prices.

In actual practice, this team operation is seldom carried to its optimum conclusion; each party performs his function with little consideration of the other's problems. As a result the piping specifications are usually sound (the engineer's demands invariably come first) but the specification frequently falls short of the most economical solution.

The very complex code governing materials and their application makes this procedure appear the only practical method. After the engineer selects a good material, the purchasing agent can only negotiate for the best source.

Here's another very real solution to this problem and possibly more practical for the average user of piping materials. Turn the problem around and let the purchasing agent (P.A.) get his plugs in first (in the form of a recommendation). This can make the engineer's job much easier.

Pipe—The P.A. tabulates regularly available piping materials listed by the Code (ASA for Pressure Piping) in order of their base cost per 100 feet. This information is not readily available, preparing this tabulation is real work. The piping code lists some 260 different materials not counting some of the variations in grade and method of manufacture that are a little obscure. Usually he can develop sound prices for about 40 of these materials. Others are not commercially available—are produced in limited sizes—on special mill orders only—or for some other reason cannot be considered regular piping materials.

This list will start to pay dividends in many ways. First, engineers will not design for material that cannot be obtained and the price range will guide them to the most oconomical material. Some materials seem downright cheap while others are so very dear that only extreme conditions would warrant their consideration. Actually the pipe alone will range in price 1 to 45 from welded A-120 to seamless stainless steel Type 310. The picture at this stage, however, is far from complete for the system must have flanges and fittings.

Flanges and Fittings—The offerings are even less if this same pricing procedure is followed in selecting flanges. The mills will furnish flanges and fittings in almost any material desired but if the selection is one not regularly furnished, there is a set up charge and long delivery. The normally manufactured materials are restricted in alloy variations, do not have a variety of manufacturing procedures, and range in price 1 to 14 from carbon steel to Type 310 stainless.

This narrower price range can be accounted for by the ratio of labor to raw material. Pipe carries a relatively low labor factor while flanges and fittings carry a much higher percentage of labor tending to level out the prices of these components.

Fabrication—In fabrication the ratio of costs from the simplest carbon steel

to the most difficult alloy steel operations embraces a range of 1.0 to 4.3. This includes variations in the weldability of the various alloys and the stress relieving and heat treatment when required.

Three other factors are involved in a piping system before it can be considered complete but these are outside the scope of this analysis. Most important of these is valve selection. The number and type of valves used can be varied by the designer to such an extent that including values in the over-all analysis would limit its use. Piping erection and testing are then the remaining factors. These are thought to represent a constant addition to the previous costs and would not necessarily vary with the selection of the material and therefore could be eliminated without effecting the result.

To qualify this analysis further the data has been taken from average refinery and chemical plant installations considered representative of the

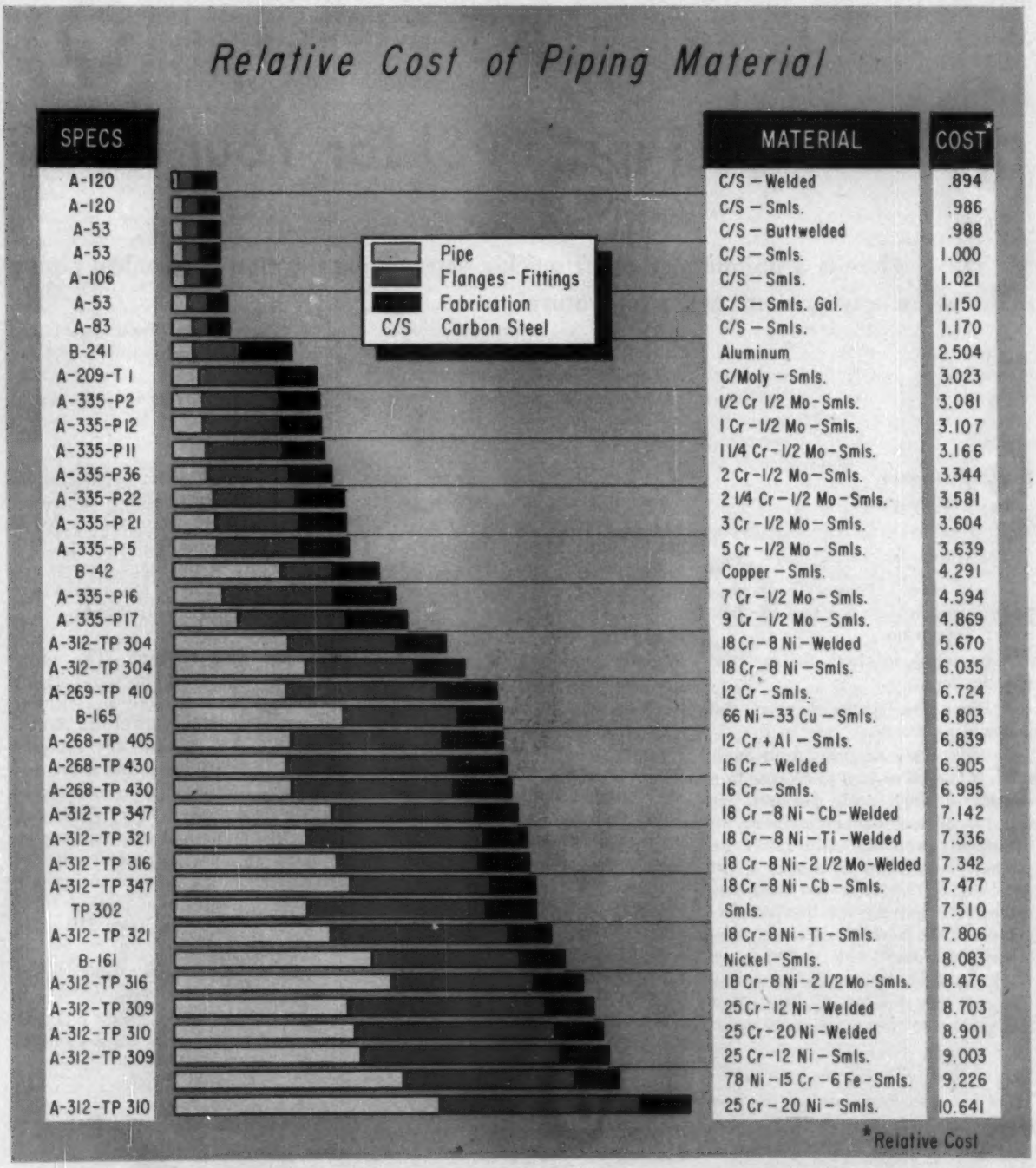

Relative Cost of Piping Material
SPECS
MATERIAL
COST*
Pipe
Flanges - Fittings
Fabrication
C/S Carbon Steel
A-120 C/S — Welded .894
A-120 C/S — Smls. .986
A-53 C/S — Buttwelded .988
A-53 C/S — Smls. 1.000
A-106 C/S — Smls. 1.021
A-53 C/S — Smls. Gal. 1.150
A-83 C/S — Smls. 1.170
B-241 Aluminum 2.504
A-209-T 1 C/Moly — Smls. 3.023
A-335-P2 1/2 Cr 1/2 Mo - Smls. 3.081
A-335-P12 1 Cr - 1/2 Mo - Smls. 3.107
A-335-P11 1 1/4 Cr - 1/2 Mo - Smls. 3.166
A-335-P36 2 Cr - 1/2 Mo - Smls. 3.344
A-335-P22 2 1/4 Cr - 1/2 Mo - Smls. 3.581
A-335-P 21 3 Cr - 1/2 Mo - Smls. 3.604
A-335-P 5 5 Cr - 1/2 Mo - Smls. 3.639
B-42 Copper — Smls. 4.291
A-335-P16 7 Cr - 1/2 Mo - Smls. 4.594
A-335-P17 9 Cr - 1/2 Mo - Smls. 4.869
A-312-TP 304 18 Cr - 8 Ni - Welded 5.670
A-312-TP 304 18 Cr - 8 Ni - Smls. 6.035
A-269-TP 410 12 Cr - Smls. 6.724
B-165 66 Ni - 33 Cu - Smls. 6.803
A-268-TP 405 12 Cr + Al — Smls. 6.839
A-268-TP 430 16 Cr — Welded 6.905
A-268-TP 430 16 Cr — Smls. 6.995
A-312-TP 347 18 Cr - 8 Ni - Cb - Welded 7.142
A-312-TP 321 18 Cr - 8 Ni - Ti - Welded 7.336
A-312-TP 316 18 Cr - 8 Ni - 2 1/2 Mo - Welded 7.342
A-312-TP 347 18 Cr - 8 Ni - Cb - Smls. 7.477
TP 302 Smls. 7.510
A-312-TP 321 18 Cr - 8 Ni - Ti - Smls. 7.806
B-161 Nickel - Smls. 8.083
A-312-TP 316 18 Cr - 8 Ni - 2 1/2 Mo - Smls. 8.476
A-312-TP 309 25 Cr - 12 Ni - Welded 8.703
A-312-TP 310 25 Cr - 20 Ni - Welded 8.901
A-312-TP 309 25 Cr - 12 Ni - Smls. 9.003
78 Ni - 15 Cr - 6 Fe - Smls. 9.226
A-312-TP 310 25 Cr - 20 Ni - Smls. 10.641
*Relative Cost

FIGURE 1—Relative price of pipe, flanges and fittings and fabrication for various code materials.

industry. All specifications to the ASA Code For Pressure Piping Within Refinery Limits.

The total relative cost for any piping material is found by adding the cost of pipe, fittings and fabrication in their proper perspective. This has been estimated in carbon steel as 27½ percent piping materials, 30 percent fittings and flanges and 47½ percent fabrication. The analysis applies in its entirety to pipe sizes 2 inches and larger that are normally welded. For sizes smaller than 2 inches the fabrication factor has not been fully verified since this is usually a field operation.

The total piping system will therefore vary in cost from 89 cents for A-120 butt welded carbon steel to $10.64 for Seamless Type 310 stainless steel. While this represents a tremendous range of costs for a given piping system it does not seem nearly as foreboding as the range of 45 to 1 for the pipe alone.

Figure 1 shows the relative price for pipe, flanges and fittings and fabrication for various materials. Even with these data assembled the piping material is still not dictated for it must meet the engineers operating demands. This is primarily the ability to withstand conditions of temperature, pressure and corrosion. The first two of these factors is spelled out in the code as the allowable "S."

For every piping material at every operating temperature a safe allowable working stress is set forth. From these tables in the code, relative strengths of various materials are at once apparent. Both the strongest and the cheapest piping materials have been determined but unfortunately neither is the most economical for the average job. If the allowable "S" for any particular material at any temperature is divided by the relative price of that material a true index of the relative economy of that particular material is established. This indicates how much "S" you get for your dollar or, conversely, how many psi the dollar will buy. This is shown in Table 1. The shaded figures represent the most economical material for that particular temperature.

Information in Table 1 now becomes the working background from which piping material may be selected with full knowledge of the costs involved. As a working tool, it will clear up some of the most perplexing and commonly misunderstood piping specifications, as well.

Pipe is generally referred to either as pipe or as tubing, but these two terms are not quite synonymous, for they carry a different set of rules. For the most part, piping materials are available either under a piping specification or a tubing specification; so to avoid confusion, it is generally desirable to use only the piping specification.

The main differences in tubing specifications that will affect the piping engineer are:

1. He must specify outside diameter and wall thickness instead of nominal diameter and schedule.

2. He must recognize a difference in tolerance in wall thicknes.

3. He must recognize a difference in calculated strength (due to dimensional differences).

All of this explanation leads to only one important practical consideration —*You can't buy seamless pipe A-53 or A-106 in sizes smaller than 2-inch diameter.*

The ASTM standards for piping material lists sizes from ⅛-inch to 24-inch, but since they are not commercially available, the next seamless material is A-83, defined as "Seamless Steel Boiler Tubes."

A second point of frequently confused specification is the designation of material grade. Some of the piping specifications are further divided by grades, representing a variation in the chemistry of the material, a variation in the physical properties, or both. Sometimes the grade designations are called types. It is, therefore, important to read all of the "fine print" to be sure that the grade designation for any particular material is fully understood.

For carbon steels A-53 and A-106 in Grades A and B, the chemistry variations are small or not stated, while the allowable "S" of Grade B exceeds that of Grade A by 25 percent. There are, however, two limitations on the use of Grade B pipe— it is not suitable for flanging or for close coiling. Since these are not normal piping requirements, they may be excluded from most specifications permitting the use of Grade B pipe throughout.

About the Author

Dan Christopher is marketing manager for Gray Tool Co., Houston. Since receiving his B.S. degree in mechanical engineering from the University of Illinois in 1933, he has been assistant engineering manager of the Houston office of Foster Wheeler Corp., merchandising manager for Ideal Industries, Inc., and field engineer for Norma Hoffman Bearings Corp.

From time to time, relative weldability of Grade A and B arises. The leading pipe fabricators recognize no difference in price for welding these two materials; therefore, the difference must be very slight.

The price of A-53 or A-106 is the same in either grade, so that the greatest demand is for Grade B and this is most frequently stocked in the warehouses.

To attempt to apply the previous explanation to material A-83 would cause considerable error. First of all, A-83 is available in types A, B and B alt. Type A is a low carbon seamless steel material, but types B and B alt. are iron.

The ASA Code for Pressure Piping does not recognize A-83 type B as a grade variation, but since it is iron rather than steel, it is so classified. The type A (even though specified as a seamless material) is rated both as seamless and welded. A-83 type A, therefore, carries the same allowable "S" as A-53 Grade A.

The range of available sizes of A-83 does not overlap with the sizes of A-53; therefore, no direct price comparison can be made. By extrapolation, however, A-83 appears to cost 79 percent more per foot than A-53. Since the allowable "S" of A-83 is 20 percent less than A-53 Grade B, the over-all economy based on "S"/$ then becomes 68 percent, which seems like a high premium to pay for seamless material under 2-inch size.

On the other hand, if A-53 Grade B Electric Resistance Welded is avail-

TABLE 1

Allowable "S" Per Dollar. The largest number for any temperature is the most economical material.

TEMPERATURE	MATERIALS																
	A-53-B E.R.W.	A-53-B Seamless	A-106-B Seamless	A-53-B Seamless Galvanized	A-83-A Seamless	B-241 Aluminum	A-209 -T1	A-335 -P2	A-335 P-12	A-335 P-11	A-335 P-3-b	A-335 P-22	A-335 P-21	A-335 P-5	B-42 Copper	A-335 P-16	A-335 P-17
—20 to 100 F	17206	20000	19589	17391	13594	1338	6070	5956	6035	5922	5607	5236	5202	5153	1699	4081	3851
200	16396	19100	18707	16609	12990	1158	5838	5728	5874	5764	5428	5096	5022	4919	1648	3885	3676
300	15586	18150	17777	15783	12319	958	5607	5501	5665	5575	5263	4929	4828	4685	1268	3700	3512
400	14827	17250	16895	15000	11725	719	5392	5290	5488	5417	5084	4789	4675	4452	634	3515	3357
500	14068	16350	16014	14217	11130	....	5160	5063	5294	5243	4919	4636	4467	4218	....	3330	3173
600	13309	15500	15181	13478	10493	....	4929	4836	5117	5069	4740	4482	4287	3985	....	3145	2999
650	12904	15000	14691	13043	10195	....	4813	4722	5037	4990	4665	4412	4204	3875	....	3047	2916
700	12348	14350	14055	12478	9898	....	4697	4609	4940	4911	4575	4328	4106	3751	....	2949	2834
750	11133	12950	12684	11261	9091	....	4581	4495	4844	4833	4486	4273	4023	3641	....	2851	2742
800	9311	10800	10578	9391	7901	....	4466	4382	4747	4738	4396	4189	3857	3517	....	2721	2660
850	7439	8650	8472	7522	6712	....	4350	4268	4570	4548	4187	4021	3625	3408	....	2503	2567
900	5567	6500	6366	5652	5525	....	4135	4057	4216	4138	3738	3658	3330	3160	....	2068	2465
950	....	....	....	....	....	....	....	3246	3540	3474	2990	3072	2497	2748	....	1524	2218
1000	....	....	....	....	....	....	....	2029	2414	2444	1854	2178	1942	2006	....	1088	1746
1050	....	....	....	....	....	....	....	1298	1609	1737	1256	1620	1526	1429	....	762	1130
1100	....	....	....	....	....	....	....	799	901	1263	822	1173	1110	907	....	544	678
1150	....	....	....	....	....	....	....	....	....	790	523	838	749	605	....	327	452
1200	....	....	....	....	....	....	....	....	....	379	359	559	416	412	....	261	308
1250	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1300	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1350	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1400	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1450	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

	MATERIALS																
	A-312 Type 304 Welded	A-312 Type 304 Seamless	A-268 Type 410 Seamless	B-165 Monel Seamless	A-268 Type 405 Seamless	A-268 Type 430 Seamless	A-312 Type 347 Welded	A-312 Type 321 Welded	A-312 Type 316 Welded	A-312 Type 347 Seamless	A-312 Type 321 Seamless	B-161 Nickel Seamless	A-312 Type 316 Seamless	A-312 Type 309 Welded	A-312 Type 310 Welded	A-312 Type 309 Seamless	A-312 Type 310 Seamless
—20 to 100 F	2822	3107	2789	2528	2742	2859	2240	2181	2179	2508	2402	1237	2212	1838	1797	2083	1762
200	2496	2750	2662	2425	2588	2716	2240	2181	2179	2508	2402	1237	2212	1838	1797	2083	1762
300	2249	2486	2528	2278	2435	2573	2023	1970	2070	2274	2178	1237	2212	1689	1769	1922	1738
400	2046	2262	2402	2175	2281	2430	1876	1827	2029	2113	2024	1237	2065	1632	1741	1855	1710
500	1869	2071	2275	2161	2135	2287	1806	1758	1989	2033	1947	1237	2029	1620	1691	1844	1663
600	1737	1922	2142	2161	1981	2144	1778	1731	1982	1993	1908	....	2017	1614	1640	1833	1616
650	1675	1856	2075	....	1901	2073	1771	1724	1975	1986	1902	....	2012	1609	1618	1827	1588
700	1623	1790	2015	2161	1820	2001	1764	1718	1968	1980	1896	....	2006	1603	1584	1822	1560
750	1561	1723	1948	....	1725	1930	1750	1704	1954	1966	1883	....	1994	1580	1550	1799	1527
800	1499	1657	1896	2131	1608	1873	1729	1683	1941	1946	1864	....	1976	1534	1500	1744	1475
850	1455	1607	1800	....	1477	1787	1701	1656	1907	1912	1832	....	1947	1453	1427	1655	1400
900	1411	1558	1636	1176	1331	1673	1680	1636	1852	1886	1806	....	1888	1344	1314	1533	1297
950	1367	1508	1309	....	1170	1315	1652	1608	1743	1852	1774	....	1781	1218	1191	1388	1175
1000	1323	1458	952	....	585	929	1610	1568	1621	1805	1729	....	1652	1022	1050	1166	1034
1050	1270	1408	....	....	....	....	1554	1513	1416	1752	1678	....	1439	827	932	944	667
1100	1129	1243	....	....	....	....	1484	1449	1205	1672	1601	....	1227	632	809	722	470
1150	864	953	....	....	....	....	952	927	981	1070	1025	....	1003	488	691	555	338
1200	670	746	....	....	....	....	595	579	790	669	641	....	802	373	573	422	235
1250	485	539	....	....	....	....	427	416	613	481	461	....	625	281	455	322	136
1300	370	406	....	....	....	....	322	314	463	361	346	....	472	224	337	255	70
1350	273	298	....	....	....	....	238	232	347	267	256	....	354	172	225	194	42
1400	212	232	....	....	....	....	182	172	272	207	199	....	277	126	152	144	33
1450	150	166	....	....	....	....	140	136	211	160	154	....	216	86	107	100	23
1500	115	124	....	....	....	....	119	116	177	134	128	....	177	75	73	83	19

able, the relative economy becomes 17,206/20,000 or 86 percent, making this by far the most logical choice for the very large demand for pipe ½-inch, ¾-inch, 1-inch and 1½-inch, found in almost any plant.

Most companies specify that drinking water and instrument air be carried in galvanized steel pipe. Should these specifications be coupled with "all seamless" the budget is in for a real beating in the small sizes. The poor economic characteristics of A-83 Boiler Tubes is compounded by the fact that this material is not galvanized at the mill and must be performed as a subsequent operation by another vendor. The purchaser is then without grounds on which to bargain.

MOST ECONOMICAL PIPING MATERIAL

Temp.	Material
—20 to 900 F	A-53—Grade B Seamless.
950	A-335—Grade P-12 Seamless
1000	A-335—Grade P-11 Seamless
1050-1150	A-312—Type 347 Seamless
1200-1500	A-312—Type 316 Seamless

This problem is particularly tough if his requirements are so low that he must depend solely on warehouse stocks. No attempt has been made to measure the actual cost of this galvanized material, but it has been found to range from high to unreasonable.

On the other hand, A-53 welded and galvanized at the mill offers a final cost ratio of about "S"/$, 13,-920/20,000 or 69 percent, which does not seem unreasonable.

Throughout the balance of the analysis, the economic preference for various materials is clearly defined. If, for any reason, factors other than pressure and temperature become dominant, the "S"/$ values in Table 1 will still indicate the most economic material after all other prerequisites are satisfied—if there is a choice.

It is interesting to note the regular advantage of seamless over welded pipe in all temperature ranges. In stainless steel consideration, these factors cannot be applied blindly to all applications. They will be most applicable for materials Schedule 40 and heavier, but should the requirements be for Schedule 5 or 10 material, the welded pipe may be preferred. # #

How to Estimate Piping Labor

Using the units given here you can quickly estimate the man-hours required to fabricate and erect carbon steel piping.

O. R. Roberts,
Englewood, Colo.

PIPING LABOR is one of the most difficult, most controversial and most important labor items in a refinery or chemical plant estimate.

Here is a table of labor units and a method for estimating piping labor. It can be used for a large or small project, a single line or a change order—either addition or removal of piping.

Piping labor only is of primary concern here, therefore, material costs will not be considered. Piping materials are subject to variable discounts —depending on quantity, geographic location, delivery schedule, etc. Current costs can best be obtained from normal supply sources and estimating price sheets set up for each situation.

Assume a flowsheet, piping specs and a plot plan or other piping drawings are available and a bill-of-material prepared. Using the table of labor units and bill-of-material a piping labor estimate can be made.

Using the bill of material make the following "lists" and apply the labor units from the table: (See sample bill of material and list of labor units.)

1. **Butt-Welds.** List the welds by size and weight (Standard or Extra Heavy). Count two welds for an ell, three for a tee, one for a flange, etc.

   Do not count welds for straight pipe in a process area. However, on long runs of yard lines where several joints of pipe are butted together the welds should be counted.

   Count slip-on flanges as one butt-weld, mitre welds as 1.5 times a butt-weld, stub-in at 2 times a butt-weld and a stub-in with reinforcing saddle at 3 times a butt-weld. (Mitre and stub-in welds will have to be taken from drawings.)

   Apply the labor units, from the table, for each size and weight of weld and extend the totals.

   These units include all fabrication labor, such as (1) gathering materials, (2) cutting and beveling, (3) assembly (tack weld), (4) welding, (5) checking, (6) stencil piece numbers, (7) direct supervision and (8) extra time for welds made "in place" during the erection and assembly of fabricated pipe.

   Not included non-productive labor such as shop superintendent, sketching, accounting, etc.

2. **Flanged Joints.** List the number of flanged joints by size and rating —one joint for each flange. (Where pipe is made up with flange joints for assembly, count one joint for two flanges.)

   The units include all the labor for installing the gasket and bolting up service tight.

3. **Handle Flanged Valves.** List the number of valves by size and rating.

   The units inlcude all labor to (1) receive, (2) store, (3) move into area and (4) erect and align for bolting up. (Bolting up is in flanged joints.)

4. **Handle Pipe.** List the lineal feet of pipe by size and weight. The units include all labor to (1) receive, (2) store in racks, (3) move into area (fabricated and straight) and (4) erect and align on racks for bolting up or welding in place. (Does not include bolting or welding.)

5. **Screw Joints.** List the number of joints by size. Count two joints for each ell, valve, union, etc. Tees are counted as three. Do not count pipe nipples or swage nipples.

   The units include all labor to (1) receive and store, (2) move into area, (3) cut and thread and (4) fit up service tight.

Multiplying the number of each item by the labor unit and extending the result gives the "basic estimate" of man-hours of labor required.

Up to this point the beginner estimator can do the work. The units give him something to work with—to get the feel of estimating piping labor. They represent the normal or average job.

But now the experienced estimator must take over. The estimate depends upon his experience and judgment for the additional labor that is required for variable working conditions that affect the job. He must make adjustments to the "basic estimate" to get the total man-hours required.

The table of units are indicative of efficient management, competent mechanics, sufficient tools and favorable working conditions. They apply to typical refinery and chemical plant

units with pumps, exchangers and other equipment installed outside and with piping laid on overhead structural supports. They include all the crafts required to handle and install the piping—welders, fitters, helpers, truck drivers and crane operators.

The estimator should make a complete analysis of the job to be estimated—size, arrangement, access to the area, location of work space and storage space, local labor problems and other conditions that will affect the job. With all these at hand the estimator can compile the job factor for adjusting the "basic estimate".

Here are some typical examples of "adjustments" which the estimator must make to the "basic estimate":

Supervision—the table of units includes one pusher foreman for each crew of seven to nine journeymen. The area foreman must be added to this at the rate of one for each three crews—(4 percent-5 percent of the "basic estimate"). .....4-5 percent.

The piping superintendent (when required) should be carried in the field staff account.

Testing—ordinary testing with water or air, normal adjustment of packing glands and follow up on bolted joints (this will be affected by the kinds of material).....3-7 percent.

Quality of Labor—some areas produce more work per man-hour than others. This involves the human element and is probably the most difficult for the estimator to evaluate. It is subject to the changing times—recession and boom, war and peace, etc.....5-25 percent.

Long Hours—fatigue, inefficiency (50 hr. week)..3-5 percent. The table of units includes normal fatigue and lost time for a standard 40 hour week.

Type of job—limited access to equipment, crowded work conditions, inside buildings, extra height, etc. .....5-25 percent. In most cases this applies to only part of the work.

Weather—Extreme cold, heat, rain, snow, or wind..5-25 percent. This applies to only part of the work.

Typical Estimate for a medium size refinery unit.

This estimate is based on efficient management, competent mechanics and sufficient tools. The job is a typical refinery unit with most equipment located outside. Practically all piping is on supports ten to twelve feet overhead. The industrial area has recently completed similar projects, therefore experienced mechanics should be available. The construction schedule is based on a 40-hour work week. There are no overtime jobs operating in the vicinity.

The job area is an addition to an existing plant; however, it is open on two sides with plenty of room for storage and work space. Some severe weather with heavy snow and wind can be expected. Say 25 percent of work at 20 percent loss of efficiency (25 percent @ 20 percent = 5 percent of total).

From labor lists with unit extensions we get the following "basic estimate" of man-hours: (see "Sample" for method.)

1. Welding	8419	
2. Flange Joints	1036	
3. Handle flange valves	127	
4. Handle pipe	1792	
5. Screw joints	1038	
Basic estimated hours		12,412
Area Foreman Hours—		
5 percent		620
Test—air and water—		
5 percent		620
Weather—partial—5 percent ..		620
Total estimated hours		14,272

Estimating labor rate—the total estimated hours include pipe fitters, pusher foremen, area foremen, crane operators, truck drivers, etc.

With a crew of nine pipe fitters there is one pusher foreman. With every three crews there is one area foreman. Also about 10 percent of the total will be truck drivers, crane operators, etc.

With this arrangement the estimating rate per hour is set as follows:

27 Pipefitters ..... @ $3.00 Per Hr.	=$81.00
3 Pusher Foremen ..... @ $3.25 Per Hr.	= 9.75
1 Area Foreman ..... @ $3.50 Per Hr.	= 3.50
3 Operators (Avg.) ..... @ $2.60 Per Hr.	= 7.80
34 Man-hours @ Total Cost of...	$102.05

$102.50 / 34 Hrs. = $3.00 Per Hr. Total Average Rate

Total estimated hours	14,272
Total Average Rate per hour	3.00
Total estimated labor cost	$42,816

This cost is only direct piping labor. It does *not* include any indirect cost such as social security, insurance or fringe benefits. And it does *not* include any tools or equipment.

Summary—Labor units are the essential tools an estimator uses to establish a labor reference point. They are his standards for evaluating the labor in any project.

A necessary warning—especially to the beginner and inexperienced—no table of units can be reliable until it his been thoroughly checked against known job data of your own work performance.

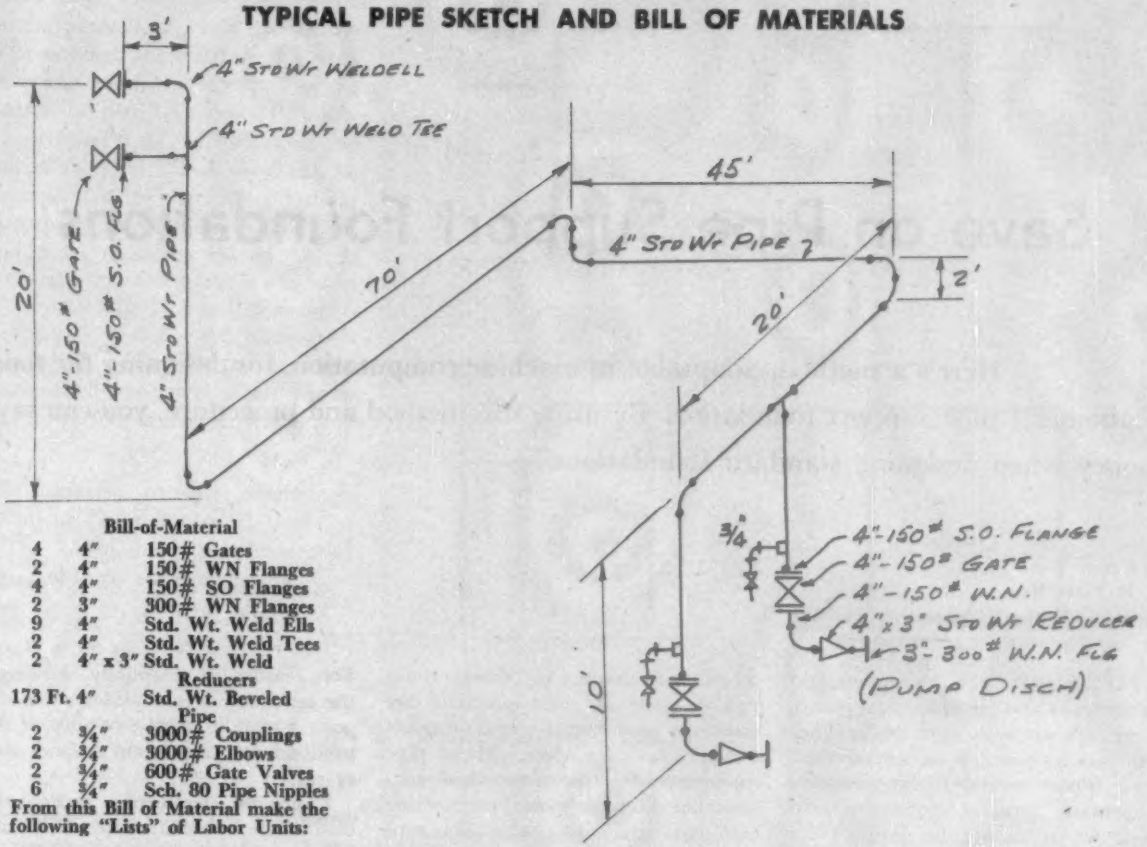
A quick preliminary check can be made against some recently completed piping projects as follows:—(1) apply the table of units against the bill-of-material from the completed job, (2) extend the hours and total for the basic estimated hours, (3) make the job factor adjustments as required for a total estimated hours, and (4) compare this total estimated hours with the actual hours used on the project. An adjustment factor can be determined for correcting the estimated hours to equal the actual hours. This adjustment factor should be used for estimating similar work.

A closer check must be made with future work where the labor can be coded and accounted to compare with the different work units. With this data can be made of the units to give accurate predictions of work performance. # #

About the Author

O. R. Roberts is a cost estimator and he makes cost estimates for chemical plants, refinery units, gas plants, compressor stations and other construction projects. Roberts has a background of 20 years experience in the process industries. He spent six years with Socony-Vacuum Oil Co. as assistant project engineer and as senior mechanical engineer at the Casper, Wyo., refinery. Roberts is a registered professional engineer in Colorado.

TYPICAL PIPE SKETCH AND BILL OF MATERIALS



Bill-of-Material

4	4"	150# Gates
2	4"	150# WN Flanges
4	4"	150# SO Flanges
2	3"	300# WN Flanges
9	4"	Std. Wt. Weld Ells
2	4"	Std. Wt. Weld Tees
2	4" x 3"	Std. Wt. Weld Reducers
173 Ft.	4"	Std. Wt. Beveled Pipe
2	¾"	3000# Couplings
2	¾"	3000# Elbows
2	¾"	600# Gate Valves
6	¾"	Sch. 80 Pipe Nipples

From this Bill of Material make the following "Lists" of Labor Units:

Piping Labor List—made from above sketch and bill-of-materials.

No. Butt-welds Units	Unit	Hours
4" Std. Wt. WN Flanges 2		
SO Flanges 4		
Weld Ells 18		
Weld Tees 6		
Reducer 2		
Total 32	@ 2.5	80.0
3" Std. Wt. WN Flanges 2		
Reducer 2		
4	@ 2.0	8.0
¾" Couplings 2	@ 0.9	1.8
Flanged Joints 4"—150# 6	@ 2.0	12.0
3"—300# 2	@ 2.5	5.0
Handle Flange Valves 4"—150# 4	@ 1.0	4.0
Handle Pipe 4" Std. Wt. 173 Ft.	@ .27	46.7
Screw Joints ¾" Gates 4		
¾" Elbows 4		
¾" Couplings 2		
10	@ .40	4.0
Total Basic Estimated Hours		161.5

Carbon Steel Piping Labor Units (Hours)

Pipe Size	Buttwelds Std. Wt.	Buttwelds Ex. Ex. Hy.	Flange Joint 150	Flange Joint 300	Handle Flg. Valve 150	Handle Flg. Valve 300	Handle Pipe Std. Per Ft.	Handle Pipe Ex. Hy. Per Ft.	Screw Joints	Pipe Size
¾	.90	.95	1.5	1.5			0.7	0.8	.40	¾
1	.95	1.00	1.5	1.5			0.8	0.9	.50	1
1¼	1.00	1.10	1.5	1.5			0.9	.11	.60	1¼
1½	1.1	1.3	1.5	1.5	.5	.7	.10	.13	.80	1½
2	1.3	1.5	1.5	2.0	.6	.8	.13	.15	1.20	2
2½	1.7	1.9	2.0	2.0	.7	.9	.18	.21	1.50	2½
3	2.0	2.2	2.0	2.5	.8	1.0	.21	.25		3
4	2.5	2.8	2.0	2.5	1.0	1.3	.27	.33		4
6	3.3	4.0	2.5	3.0	1.5	2.0	.39	.52		6
8	4.0	5.0	2.5	3.0	2.0	2.5	.52	.68		8
10	5.0	6.0	3.0	3.5	2.5	3.3	.66	.81		10
12	6.5	7.8	3.0	3.5	3.0	4.0	.76	.90		12
14	7.2	8.5	3.0	4.0	3.6	5.2	.80	1.00		14
16	7.8	9.0	3.5	4.0	4.3	6.2	.90	1.10		16
18	9.0	10.2	3.5	4.5	5.0	7.6	1.00	1.20		18
20	10.0	12.0	4.0	4.5	5.6	8.6	1.05	1.25		20
24	12.0	14.5	4.0	5	7.0	9.0	1.20	1.40		24

Where labor units are taken from the bill of material some butt-welds are lost when joints of pipe are welded together. Also some flanged joints are lost when valves are bolted direct to equipment. However, in process areas, this is generally made up by butt-welds saved when fittings are welded together. An example of this is the weld neck flanges, weld ells and reducers welded together at the pump discharge.

Save on Pipe Support Foundations

Here's a method, adaptable to machine computation, for designing the most economical pipe support foundation. By using this method and procedure, you can save money when designing standard foundations.

S. H. Fistedis,
Argonne National Laboratory, Lemont, Ill.

PIPE SUPPORTS, a common sight in refineries and petrochemical plants, carry comparatively light loads. They are usually mounted on spread footings. These spread footings involve excavation, forming, concrete and steel, which cannot be justified for lighter loads. Because of the large number of pipe supports used, considerable savings could be realized from using a more efficient type of foundation.

Pier foundations save money by reducing excavation, steel and concrete, eliminate forming in a good number of cases, and lend themselves to mass production methods in design and construction. Therefore, simple mathematical relations were developed that give the minimum size vertical pier foundation consistent with the vertical loads of a pipe support, the overturning wind forces, and make full utilization of the properties of soil. These mathematical relations, where properly coordinated with wind and pipe standards, can be programmed for electronic computation. With results tabulated for ready reference, the design of economical pipe support foundations for an entire plant can be reduced to a few hours' work.

Pipe supports are used in a variety of shapes and forms. Certain types of pipe supports are more common with some firms, not necessarily because of rational considerations, but as a matter of prior practice or "design tradition". Some of these practices are based on past special requirements which no longer exist. Many pipe supports of unique shape and construction still serve special engineering considerations. Standard pipe supports, however, are becoming more accepted.

Figure 1 shows some typical pipe supports of wide usage. The single deck and double deck bent, with or without outriggers, is the most common type. For lighter loads and fewer pipes, the single pole (Types 1 and 2) are used considerably. Irrespective of their type, pipe suports are essentially structures of identical function, and their foundation design is governed by the same requirements.

Loads on Pipe Supports. The loads resisted by pipe supports come under two classes: the horizontal wind loads, and the vertical gravity loads. The foundations should be properly designed to absorb these loads without objectionable vertical settlement or lateral displacement. Their proper design involves well known and relatively simple equilibrium and soil principles.

Types and Properties of Soils. Considerable effort has been expended toward the proper identification and classification of soils.[1,2,3]

Ordinarily, soils occur in mixtures. For reasons of simplicity, however, the tendency is to consider a soil deposit as sandy, clayey, or silty, if the predominant constituent is sand, clay or silt.

From the engineering aspect, the distinction between sands and clays is based on the interaction of their particles. Clay particles possess cohesion, whereas sand particles mobilize friction under loads. Clay soils, subjected to sustained loads, consolidate by squeezing out water over an extended period of time. Settlement of sands follows shortly after loading. In this discussion, attention will be focused on the sandy soils.

Mathematical Analysis. Let it be required to design pier foundations for a Type 4 pipe support, (Figure 1). It is assumed that a total horizontal wind thrust is resisted by the bent, and that the structure possesses a point of contraflexure at mid-height. Each leg of the bent below the point of contraflexure acts as a cantilever as shown on Fig. 2. The horizontal thrust, H/2, and the active pressure acting toward the left must be counteracted by the passive resistances in the soil on both sides of the embedded part; in this case, the pier. If the pier is rigid, it can be assumed without serious error that the variation in these pressures is hydrostatic.[4]

Figure 2(a) shows a simplified diagram of the forces acting on the pier.

The active pressure, P_1, and the horizontal thrust, H/2, are opposed by the passive pressure, P_2. For equilibrium to be satisfied, another force, P_3, must be acting toward the left, near the foot of the pier. The Force P_3 is distributed over a short length above the foot of the pier. Therefore, it can be assumed that the pier pivots[5,6] about some point above the foot, and that the passive resistance toward the left is acting below this point. If γ is taken as the unit weight of soil, d as depth of the pier, and K_p and K_a as coefficients[4] of passive and active resistances of soil respectively, the net pressure at the foot of the pier will be:

$$\gamma\, d(K_p - K_a)$$

The resulting pressure diagram is shown in Figure 2(c).

The height x can be obtained by equating forces for equilibrium.

$$H/2 - 1/2\,\gamma\, d^3\,(K_p - K_a) + \gamma\, d\,(K_p - K_a)\, x = 0$$

and if $K = K_p - K_a$

the unknown distance

$$x = \frac{1}{2}\left(d - \frac{H}{Kd}\right) \qquad (1)$$

To satisfy equilibrium, the summation of moments around the foot of the pier, should be equal to zero:

$$\frac{H}{2}\left(\frac{h}{2} + a + d\right) - \frac{1}{6}\,\gamma\, Kd^3 + \frac{1}{3}\,\gamma\, Kdx^2 = 0 \qquad (2)$$

The unknown quantities in Eqs. (1) and (2) are x and d. Since the value of x is not significant for the final design, its equivalent in Eq. (1) is substituted in Eq. (2). The resulting relation is in terms of the unknown d, the most economical depth of the pier.

$$\left(\frac{1}{12}\,\gamma K\right) d^4 - \left(\frac{H}{3}\right) d^2 - \frac{H}{2}\left(\frac{h}{2} + a\right) d - \frac{1}{12}\,\frac{H^2}{\gamma K} = 0 \qquad (3)$$

If the known quantities γ, K, h, and H are substituted in Eq. (3), the resulting arithmetical equation can be solved readily for d by the trial method.

Equation (3) applies to pipe supports Types 3 to 6 on Fig. 1. In Types 1 and 2 rigid joints between column and pier will probably make the legs of the bent act as cantilevers under wind loads, with no point of contraflexure. In this case, 2H will have to be substituted for H, and 2h for h in Eq. (3).

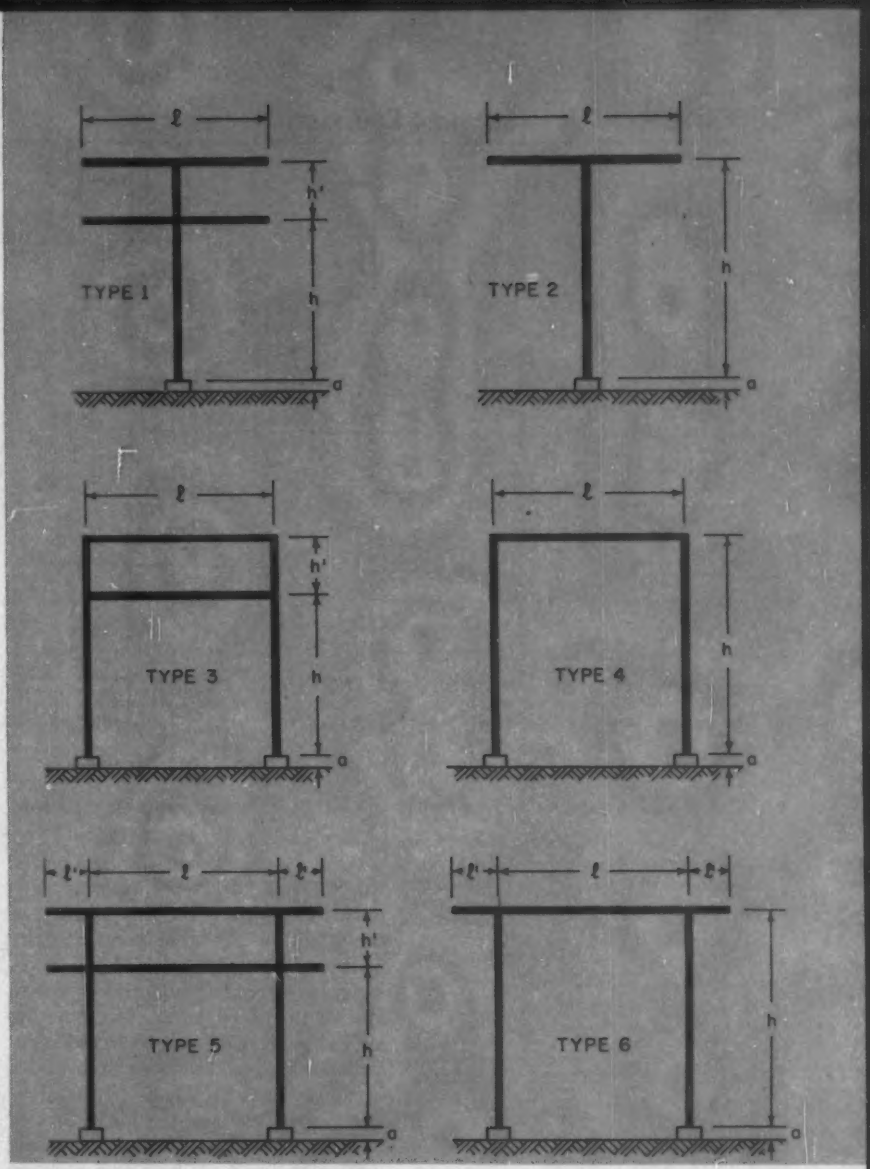


FIGURE 1—Typical pipe supports used throughout the refining and petrochemical industry.

Another possibility is to assume a pin connection for Types 3 to 6 between steel column and pier. This will necessitate rigid right angle connections at the top of the bends if the pipe support is to retain its form under lateral thrust. Under this structural configuration, the horizontal thrust is applied at ground elevation, thus eliminating the h/2 term of Eq. (3). A modified relation for this case yielding the minimum depth d is:

$$\left(\frac{1}{12}\,\gamma K\right) d^4 - \left(\frac{H}{3}\right) d^2 - \left(\frac{H}{2}\,a\right) d - \frac{1}{12}\,\frac{H^2}{\gamma K} = 0 \qquad (3a)$$

Following the determination of the minimum depth of the pier, the design of concrete and reinforcing steel is rendered a routine task.

Figure 3 shows the force system on an equivalent beam comprising the pier and the leg of the bent. The thickness of the pier and the amount of reinforcing steel are to be determined from the maximum moment. The section where the moment is maximum is the section of zero shear on the equivalent beam. To locate the section of zero shear, it is assumed that it lies within the length (d-x), a distance n from the ground level. This assumption is subsequently verified. The unknown distance n is obtained by setting the summation of all forces

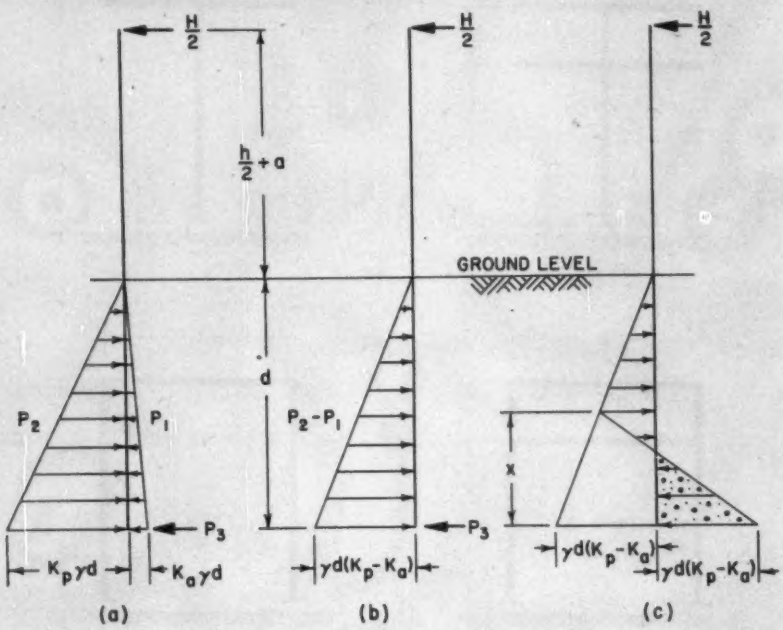


FIGURE 2—Earth pressure and force diagrams on a pier foundation for a rigid pole.

and reactions above the section of zero shear equal to zero.

$$\frac{H}{2} - (n\gamma K)\frac{n}{2} = 0 \qquad (4)$$

or

$$n = \sqrt{\frac{H}{\gamma K}}$$

The maximum moment at this section is determined by statics:

$$M = \frac{H}{2}\left(\frac{h}{2} + a + n\right) - (n\gamma K)\left(\frac{n}{2}\right)\left(\frac{n}{3}\right)$$

or

$$M = \frac{H}{2}\left(\frac{h}{2} + a + n\right) - \frac{1}{6}\gamma K n^3 \qquad (5)$$

The moment obtained in Eq. (5) is used in checking the required effective depth of the section and the amount of reinforcing steel.

Application in Design Standards. Standardization of design procedures is common practice in refineries and petrochemical plants. This standardization could either be quite rigid, or a mere repetition of design concepts. In foundations for pipe supports, standardization can prove economical.

Six types of pipe supports are indicated in Figure 1. A variation of heights and widths, (h, h′, l, and l′) will provide a good margin of selection. Table 1 shows one version of a suggested variation of dimensions for the six standard types of pipe supports. Depending on the locality of the plant, a probable wind velocity pressure could be selected.[7,8] A velocity pressure of 15 pounds per square foot of projected area, corresponding to 76.5 mph wind will be found satisfactory for a good number of localities in the continental U. S.[9] An equivalent distributed load per linear foot of rack is determined from an approximation of the total load and number of pipes that can be placed on the rack, as dictated by considerations of economy and past experience. Another variable to be determined is the distance between pipe supports. This distance will depend on the maximum permissible deflection of pipes. For a pipe support spacing of 20 feet, an equivalent distributed pipe load of 200 pounds per linear foot of rack will cover a good number of cases.

The magnitude of the total wind load applied per bent is designated by H. It includes the wind velocity pressure, the shape coefficient[9] of the pipes and pipe supports resisting the wind, the shielding effects,[9,10] the size and number of pipes, and the spacing of pipe supports.

An approximate dead load for the types of pipe supports shown on Figure 1 and their respective sizes (Table 1) can be readily obtained, tabulated, and used in conjunction with the equivalent distributed pipe load on the rack.

The weight of soil is assumed to be 100 pounds per cubic foot for the vast majority of engineering problems. Unless the weight varies substantially from this value, further refinement on this point is not justified.

The bearing capacity of soil is taken as 2000 pounds per square feet. Most sandy soils have a bearing capacity of 2000 pounds per square feet or greater.[4] It is important to note that soils with higher bearing capacities do not necessarily permit the utilization of a shallower, more economical foundation since the depth of the pier is a function only of the shearing resistance of the conical wedge of earth most likely to be pushed out by the pier.

The angle of internal friction for dry sands varies with the roundness and the gradation of the particles.[4] A low figure of 28.5 degrees corresponds to loose sands with uniform, round grains and a high of 46° defines the upper limit for dense sands with well graded, angular grains. A conservative figure of 30 degrees for the angle of internal friction of sand is commonly used.

A table similar to Table 1 can be prepared, based on the above variables as correlated by the design standards of the firm. The procedure shown under the heading, "Sample of Computations" is repeated for each line of Table 1. The simple equations employed in the computation can be easily programmed for medium range electronic digital computer. Thus, with such a table at hand, comprising the most common types and sizes of pipe supports as used by the firm, the role of the designer becomes one of comparing the weight and wind thrust of every pipe support to be designed with the corresponding quantities on the table, and selecting the most economical pier design.

The quantities of the variables discussed above have been so selected as to reflect standard practice in this phase of the industry. Substantial variations from these quantities are to be experienced in rather unique cases.

Sample of Computations

Design minimum depth piers for a type 6 bent, as shown on Fig. 4.

For a sandy soil with a unit weight of

100 lb/cu ft, and an angle of internal friction of 30°:

$$K = K_p - K_a = \frac{1 + \sin 30}{1 - \sin 30} - \frac{1 - \sin 30}{1 + \sin 30} = 2.67$$

If the wind standards for a 17′-0″ rack carrying commonly used piping with proper spacing and insulation, supported 20 feet apart, indicate a total thrust of 1380 lb/pipe support, and a pedestal height a = 1′-0″ is selected, Eq. (3), applied to a pier 2′-0″ wide* gives:

* The value of H=1380 pounds is divided by two in this case since the piers are two feet wide. Each linear foot of pier width resists one-half of the wind thrust applied to each leg.

$$\left(\frac{1}{12} 100 \times 2.67\right) d^4 - \left(\frac{690}{3}\right) d^2 - \frac{690}{2}$$

$$\left(\frac{12}{2} + 1\right) d - \frac{1}{12} \frac{(690)^2}{100 \times 2.67} = 0$$

$$22.2d^4 - 230d^3 - 2420d - 149 = 0$$

Try d = 5′-6″ $\quad -100 \neq 0$

Try d = 5′-7″ $\quad +825 \neq 0$

Use pier 2′-0″ broad, 2′-0″ wide and 5′-6″ deep. To check passive pressure at the foot of the pier:

$$K_p \gamma d = 3.00 \times 100 \times 5.5 =$$

1650 lb/sq ft < 2000 o. k.

If pipes and bent weight approximately 4,425 lb, to investigate overturning.

4425 × 6 = 26,550 lb-ft stability moment with no piers included.

1380 × 13 × 1.5 = 26,900 lb-ft overturning moment with factor of safety of 1.5

Difference:

$$-26{,}900 + 26{,}550 = -350 \text{ lb-ft}$$

Required minimum weight of each pier for a factor of safety of 1.5 against overturning:

$$\frac{350}{12} = 29.2 \text{ lb.}$$

The actual weight of each pier = (5.5 × 2.0 × 2.0 + 1.5 × 1.5) 150 = 3640 lb. To check direct bearing pressure of soil under pier, including wind effects, take moments about point 0 (Figure 4)

4425 × 6 = 26,550 moment of dead and live loads

1380 × 12 = 16,560 moment of wind load

3640 × 12 = 43,680 moment of pier dead load

86,790 lb-ft

Total soil pressure under pier:

$$\frac{86{,}790}{12} = 7262.5 \text{ lb}$$

Unit soil pressure under pier B:

$$\frac{7262.5}{2 \times 2} = 1816 \text{ lb/sq ft}$$

The bearing pressure on the soil directly under the pier will be considerably less than 1816 lb/sq ft because of the resistance to penetration offered due to friction between soil and pier.

To check the amount of reinforcing steel in the pier and the effective depth of the section, Eq. (4) yields the point of zero shear and maximum moment:

$$n = \sqrt{\frac{690}{100 \times 2.67}} = 1.61 \text{ ft}$$

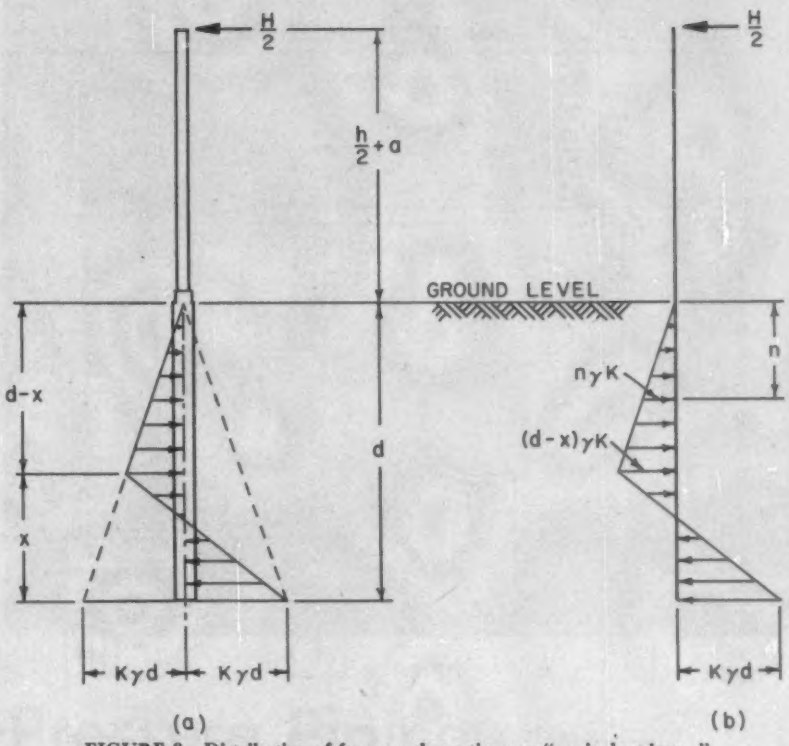


FIGURE 3—Distribution of forces and reactions on "equivalent beam."

and Eq. (5) gives the maximum moment:

$$M = \frac{690}{2}(6 + 1 + 1.61) - \frac{1}{6} 100 \times 2.67 (1.61)^3$$

$$M = 2{,}780 \text{ lb-ft} = 33{,}360 \text{ lb-in}$$

Required effective depth of the section for concrete with 2500 psi compressive strength:

$$d = 3.9 \text{ in}$$

The effective depth available in the section is 12.0 in.

The steel reinforcement provided for the pier is three ½ inch diameter bars on 6 inch centers.

Discussion. The foregoing discussion was based on the behavior of pure sands pressing against piers with smooth, flat, concrete surfaces. The conditions in practice are not so ideal. Cemented sands, silty sands, or otherwise mixed sands possess cohesion in addition to their frictional properties.

TABLE 1—Relation Between Different Types and Sizes of Pipe Supports, Wind Thrusts and Corresponding Minimum Depth Piers

PIPE SUPPORT							Maximum Wind Thrust	PIER				
	l		l′		h	h′		Breadth	Width	Depth	Reinforcing Bars	
Type	Ft.	In.	Ft.	In.	Ft. In.	Ft. In.	H Lb.	Ft. In.	Ft. In.	Ft. In.	Number	Dia., In.
1	6	0	—	—	8 0	4 0	900	1 6	2 6	6 4	3	½
2	6	0	—	—	8 0	— —	480	1 6	2 0	5 2	2	½
3	8	0	—	—	8 0	4 0	1320	2 0	2 0	5 0	3	½
3	10	0	—	—	8 0	4 0	1560	2 0	2 0	5 4	3	½
3	12	0	—	—	8 0	4 0	1800	2 0	2 6	5 2	3	½
3	14	0	—	—	10 0	4 0	2100	2 0	2 6	5 8	3	½
4	8	0	—	—	8 0	— —	720	1 6	2 0	4 0	2	½
4	10	0	—	—	8 0	— —	840	1 6	2 0	4 2	2	½
4	12	0	—	—	8 0	— —	960	1 6	2 0	4 5	2	½
4	14	0	—	—	10 0	— —	1140	1 6	2 0	4 11	2	½
5	8	0	2	6	8 0	4 0	1920	2 0	2 6	5 5	3	½
5	10	0	2	6	10 0	4 0	2220	2 0	2 6	5 10	3	½
5	12	0	2	6	10 0	4 0	2460	2 0	2 6	6 1	3	½
5	14	0	2	6	12 0	4 0	2760	2 0	2 6	6 6	3	½
6	8	0	2	6	8 0	— —	1020	1 6	2 0	4 7	3	½
6	10	0	2	6	10 0	— —	1200	1 6	2 0	5 1	3	½
6	12	0	2	6	12 0	— —	1380	2 0	2 0	5 6	3	½
6	14	0	2	6	14 0	— —	1560	2 0	2 0	6 0	3	½

Notes: Angle of internal friction of soil 30°
Soil bearing capacity 2000 lb/sq ft or greater
Unit weight of soil 100 lb/cu ft
Spacing of pipe supports 20 feet
Equivalent distributed load of pipes: 200 lb/ft of rack
Equivalent wind load on pipes: 60 lb/ft of rack for 76.5 mi/hr wind
Factor of safety against overturning: 1.5 or greater

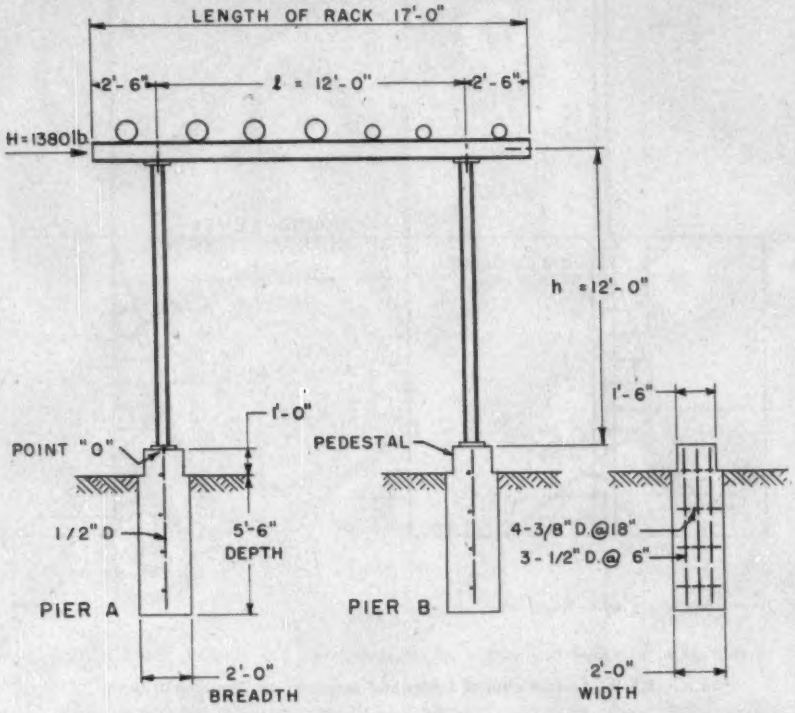


FIGURE 4—These are the typical pier details for the standard pipe support used in the sample computation.

Piers of this nature will be poured in bored holes with irregular surfaces. Both of these facts tend to increase the capacity of the pier to sustain loads and they amount to an extra margin of safety.

The tabulated results could be extended to clayey soils of 2000 pounds per square foot bearing capacity or more if the following aspects are taken into account.

- The cohesion of clays represented by their resistance to surface sliding is equal to one-half of their unconfined compressive strength.[4]
- The bearing capacity assigned to clay soils is usually equal to their unconfined compressive strength. This provides a factor of safety of three against failure by rupture.[4]

Thus, a clay soil with a bearing capacity of 2000 pounds per square foot possesses a cohesion of approximately 1000 pounds per square foot. This magnitude of resistance to sliding will necessitate much greater wind thrusts than the ones considered here, to cause the displacement of the conical wedge of earth by the piers of the dimensions tabulated.

Another point in favor of clay soils in this problem is that transient loads such as wind thrusts are inconsequential in matters pertaining to displacements, if sufficient margin against rupture has been provided.[4]

Pier foundations for pipe supports thus designed will be safe and economical. However, the engineer should exercise judgment when wet or soft soils are involved. The criterion of a minimum bearing capacity of 2000 pounds per square foot is a dependable point of departure. Piers could be circular, rather than rectangular in cross section. This, in turn, will increase the size of the pier.

Lastly a brief statement on the much discussed wind velocity pressures may be in order. Due to the special nature of the pipe support as a structure, in a long line of pipe supports, each pipe support does not have to be designed for the maximum wind velocity pressure prevalent in the locality. For instance, in a locality where maximum gusts of 100 mph have been observed and single structures are designed to sustain these forces, a long line of pipe supports could reasonably be designed for a velocity pressure of 75 miles per hour. Although it is possible that one or two pipe supports may sustain the maximum thrust, the remaining units will suffer much lesser thrusts, thus exercising a continuous restraining effect.

About the Author

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NOMENCLATURE

H = total wind thrust on pipe support
P_1 = total active pressure of soil on side of pier
P_2 = total passive pressure of soil on side of pier
P_3 = total force due to passive pressure near toe of pier
γ = unit weight of soil
K_p = coefficient of passive pressure of sand
K_a = coefficient of active pressure of sand
$K = K_p - K_a$ = difference of coefficients
d = minimum depth of pier
a = height of pedestal
h = height of single deck pipe support
n = distance from ground level to section of maximum moment in pier
M = maximum moment

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Need help on high-pressure piping—design, construction and testing? Check the following . . .

Tips for High-Pressure Piping

E. E. Ludwig,
Dow Chemical Company,
Freeport, Texas

THE CHEMICAL, petrochemical, and petroleum industries are conducting aggressive chemical research at high pressures, and developing economical production processes. Usually these processes involve pressures from 3,000 to 40,000 psi.

Research and a few applications go to higher pressures, but the industrial applications are very limited above this range.

Some proven processes which involve high pressures include:

Process	Pressure Range of Operations
1. Ammonia	3500-5000-10,000 and 15,000 psi
2. Methanol	3500-5000 psi
3. Urea	3500-5000 psi
4. Polyethylene	15,000-30,000 psi
5. Phenol	5000 psi
6. Hydrogenation of Coal and Oils	12,000-15,000 psi
7. Butyl Acetate	14,500 psi
8. Fisher-Tropsch Synthesis	3000-6000 psi

General Plant Layout

High pressure plants are usually compact, which requires careful planning. The special nature of the operation points up considerations which are of less concern for low-pressure operations. Plant safety for erection, as well as daily operations, suggests protection for personnel from ruptured or accidental failures of pipe, valves, or equipment.

Depending upon the situation, the operators can work from behind protective screens or barricades. No high pressure is brought into the control room, since remote transmitters serve to keep pressures confined to local areas. Valves may be controlled by remote air or electrical operators. Those which must be closed or opened against high pressure may require gear operators, particularly if the valve is unbalanced or relatively large for the pressures involved (above three inches) for 5,000 psi range. Operations are planned and controls arranged for a minimum of operator exposure to high-pressure equipment as a part of routine daily operations.

Influence of High Pressures on Piping

If every operation were perfectly safe regardless of the kind or arrangement of the equipment, there would be no reason for the special concern and emphasis given to high-pressure operations. Pressure is a relative factor; therefore, to those familiar with operations at 50 to 100 psi anything much above this is high. Take the next step and look at the operation at 700 psi, then any operation at 1000 psi is high, and so on up the "pressure ladder." The standardization of piping components up to 2500 psi rating has made operations with pressures through this point relatively straightforward and easy for the average situation.

Why are we concerned? First and paramount, the safety of personnel, equipment, and facilities. Second, process performance; that is, concern for a tight system, in order that the process reaction can be completed. Leaking gaskets at flanges and valves can mean the difference between expensive operations and economical product production.

The attention to complete and detailed records for all components of the piping system is worth the extra cost and effort. All specifications for

material and labor should be clearly set forth. Test records, chemical analysis, physical tests, etc., are often very valuable when studying improvements for a plant, or analyzing troubles that may have arisen. Unfortunately, this type of record keeping cannot be caught up with later, but must be done as the job progresses and the equipment is fabricated.

Let us examine some of the factors and see how high-pressure techniques come into play. High-pressure techniques may be described in several ways, but a general description would identify it as the practices, details, and know-how that allow for the safe handling of fluids or solids in confined equipment at pressures in an accepted high pressure range—for this presentation 3,500 to 40,000 psi.

Metal Thickness for Internal Pressure

Metallurgical research is continuing to delve into the performance of metals at high pressures and temperatures. The combination of these conditions presents problems separate from either high pressure or high temperature indiviually. Before metal thickness for piping can be intelligently selected, the conditions imposed upon the system must be known or established, as they influence many steps in the evaluation. These conditions include:

1. Materials of Construction. Corrosion of metals in the presence of system fluids is usually an important consideration. Unsuspected corrosion can be extremely dangerous, thus it is important to establish the entire corrosive environment, including both inside and outside conditions. In dealing with high pressures, as much of the "guess work" as possible must be taken out of corrosion. Regardless of the sources, the corrosion type and approximate rate must be identified and either allowed for, or eliminated in some rather positive manner. Some general examples of common corrosion trouble makers are:

a. Hydrogen—promotes embrittlement in carbon steel.
b. Hydrogen sulfide—promotes corrosion and blistering in carbon and some alloy steels.
c. Nitrogen—promotes nitriding in carbon steel under some conditions.
d. Carbon monoxide—promotes severe attack in carbon and alloy steels in presence of hydrogen.
e. Chemicals—many chemicals promote attack on carbon, alloy, and stainless steels.

External corrosion must also be considered. Usually good maintenance practices (such as painting) around high-pressure plants reduce this factor, but it must be considered, particularly with reference to the piping material selected for the process.

The process naturally dictates or indicates some preferred materials or sets the key considerations, and the other factors must be considered in this relationship. For example, the problem of hydrogen embrittlement at 5,000 psi using carbon steel at room temperature is almost nonexistent; however, at higher pressures or higher temperatures (above 400 F), the use of some alloy material such as chromium is beneficial. The works of Nelson and Effinger,[6] Van Ness and Dodge,[7] and Schuyten[8] are helpful in this type of consideration.

Chemical composition and physical properties of the various materials are also important in selecting material for pipe and fittings. Next, strength of the material, which is influenced tremendously by chemical composition.

"Ultimate strengths" of material (satisfactory for conventional low-pressure practices), are not sufficient, as yield point and creep data now become important. Some materials creep at relatively low temperatures if the pressure is high enough, others require high temperature in addition to pressure. The "strongest" material is not necessarily the best for a high-pressure design, since hardness, ductility, weldability, and other factors must be considered. Table 1 presents a few materials in use in certain selected applications.

Fittings are usually similar in material specifications to the pipe. For any A.S.T.M. specification for pipe there is usually a companion specifiication for welded or screwed fittings. In general, the system should be compatible to avoid unnecessary expenses and insure uniform safety in the system. This does not necessarily mean that the wall thicknesses, strengths, and other physical characteristics will be exactly the same, but rather that they will be close and also compatible for welding.

2. Normal Operating and Test Pressures—With so many formulas to choose from, design engineers must carefully evaluate operating and test conditions in terms of the better recognized relations. Quite often test conditions will control, and then the testing cycle must be established.

Testing once in ten years is entirely different from every six months (repairs usually) to one year. The pressure level of retesting might well be different than the initial installation and/or factory test, and is sometimes lowered 25-50 percent. Some examples of design and test conditions are as given in Table 2.

TABLE 1

Materials Used in High Pressure

IDENTIFICATION	Partial Specification	General Application	Operating Pressure Range
ASTM, A:106B, C.S.	Normal carbon 0.35, Y.P. 60,000 psi	Ammonia	3,500-8,000 psi
	Low carbon 0.20-0.30, Y.P. 48,000 psi	Ammonia	3,500-8,000 psi
ASTM, A-106B, C.S.	Y.P. 60,000 psi	Hydrogenation	10,000 psi
SAE 4130X, C.S.	Y.P. 60,000 psi	Ammonia	5,000 psi
ASTM, A-192-40, C.S.	Y.P. 26,000; C 0.18, Mn 0 63	Ammonia	5,000 psi
AISI, 4340	Y.P. 120,000 psi	Hydrocarbon	15,000-30,000 psi
AISI, 4140	Y.P. 60,500 psi	Hydrocarbon	15,000-30,000 psi
API, 5L Gr C*	Y.P. 45,000 psi (0-375 °F)	Hydrogenation	10,300 psi
SAE, 4130*	Y.P. 60,000 psi (0-375 °F)	Hydrogenation	10,300 psi
SAE, 1030*	Y.P. 45,000 psi (0-375 °F)	Hydrogenation	10,300 psi
ASTM, A-105 Gr. 2*	Y.P. 36,000 psi (0-375 °F)	Hydrogenation	10,300 psi
ASTM, A-335 Gr. P 9*	Y.P. 82,000 psi (376-850 °F)	Hydrogenation	10,300 psi
ASTM, A-182*	Y.P. 45,000 psi (376-850 °F)	Hydrogenation	10,300 psi
AISI, Type 316*	Y.P. 30,000 psi (851-1000 °F)	Hydrogenation	10,300 psi
AISI, Type 304*	Y.P. 30,000 psi (376-850 °F)	Hydrogenation	10,300 psi
AISI, Type 410	Y.P. 115,000 psi	Hydrocarbon	15,000-40,000 psi
AISI, Type 430	Y.P. 95,000 psi	Hydrocarbon	15,000-40,000 psi

* Reference (4)

TABLE 2

Operating Pressure	Initial Test	Retest	Frequency of Retest*
3,000	4,500	4,500	Every 5 years
5,000	7,500	7,500	Every 3-5 years
5,000	7,500	6,000	Every 5 years
5,000	10,000	10,000	Every 2 years
5,000	10,000	7,500	Every 1 year
15,000	18,000	18,000	Every 1-2 years
25,000	28,000-32,000	30,000	Every 1 year
25,000	40,000	40,000	Every 1 year

* Other than repairs.

3. Factors of Safety are in reality "factors of ignorance," particularly in high-pressure operations. Factors of safety may be referenced to a variety

of conditions, but usually resolve into a percentage factor or fraction which prevents operating stresses from reaching yield or bursting stress conditions.

The situation must be accepted, and factors of safety selected which are just that—factors which will keep all known or anticipated operating and test conditions in the area of safety for personnel and equipment.

How is this done? First, there are a lot of opinions regarding safety, and since some people are more prone to "take chances" than others and still feel safe—safety becomes a relative matter. Second, man-made materials are never perfect and, as will be discussed later, many mathematical relations are used in trying to predict the behavior of materials under the system pressure and temperature of normal operating and test conditions.

Materials are unpredictable, and each lot may perform differently.

Variations of constituents and impurities in carbon, alloy, and stainless steels can have considerable effect upon metal behavior. Heat treatment, or the lack of it, can produce startling results. All of this concerns factors of safety. The tabulation of Table 3 presents some of the practices of industry today.

In general, good practice bases factors of safety on the yield point of the material, taking into account the relationship of the yield point to the ultimate strength. For most situations, the factor of safety should be referenced to the yield point under test conditions rather than operating pressure, since a condition of yielding on test may not be safe nor acceptable, even though there is no failure in terms of bursting or rupture.

TABLE 3

Company	Operating Pressure Range	Test Conditions Factor of Safety*	Material
1	3,500-5,000	1.05-2.3	Low carbon steel
2	3,500-5,000	1.5	Carbon steel
3	10,000-15,000	1.2	Carbon steel
4	20,000-35,000	1.05-2.0	Stainless steel

* Based on yield point of material and depends upon the formula selected and the physical properties of the metal. Average factors given.

4. Type of System Assembly—The final erection assembly of the piping system influences the selection of the piping material. A welded piping system requires good weldable material, thereby eliminating some high-strength material which might give thinner wall thicknesses. A threaded system allows the use of some very high-strength materials, but necessarily places more joints and gaskets in the system as possible leak points. If the pipe or tubing is to have external or internal threads, allowance for the loss in effective wall thickness must be considered. For some joint designs there is no net loss, for others there is a slight loss due to normal fabrication or assembly techniques. This assembly must be considered in evaluating wall reduction for threading.

The use of long radius sweeping bends is recommended in practically all high-pressure assemblies. Usually a radius of bend equal to five pipe diameters is good, but the results on a particular pipe should be checked to be certain that excessive wall thinning does not occur in the bend. Some data on the thinning of carbon steel (0.30 maximum carbon) when bent cold on mandrels is given in Table 4.

TABLE 4

Bend	Nominal Pipe Size	Radius of Bend	Material	Percent Outer Wall Thinning
180°	1¼" x 0.452" w.t.	8⅝"	ASTM-A106B	3.75
180°	1¼" x 0.29" w.t.	3½"	ASTM-A106B	Negligible
90°	1½" x 0.517" w.t.	9"	ASTM-A106B	8.7
90°*	1½" x 0.517" w.t.	7½"	ASTM-A106B	8.7

* Bent hot, sand filled.

5. Wall Thickness Formulas—The mathematical treatments which have been investigated to establish or predict the metal wall thickness are many and varied. The selection of the "one" to use is often influenced by a company's attitude toward safety, the feeling of reliability of the formulae, and the general engineering approach to problems of this nature.

It is interesting to note that in the early 1930's the practice for wall thickness determination was stated by Tongue[2] as shown in Table 5.

TABLE 5

Pressure Range	Diameter Ratio O.D. / I.D.	Material
Up to 300 atms	2	Solid-drawn seamless copper
300-500 atms	4	Solid-drawn seamless copper
Up to 300 atms	2	Solid-drawn mild steel
300-750 atms	3	Solid-drawn mild steel
750-1,500 atms	4	Solid-drawn mild steel

This means that for 300 atms a 2-inch outside diameter copper tube had a 1-inch bore. For comparison and reference to today's understanding of the subject, Table 6 using the arrangement of Burrows, et. al.,[1] lists some of the most prominent of the pipe wall thickness and stress calculation formulas.

TABLE 6

Authority	Formula
ASA B31 Task Force	$t = \frac{pD}{2S + 2yp}$
	Temp. F: 900° & Below; 950°; 1000°; 1050°; 1100°; 1150° & Above
	y, Ferritic: 0.4; 0.5; 0.7; 0.7; 0.7; 0.7
	y, Austenitic: 0.4; 0.4; 0.4; 0.4; 0.5; 0.7
Soderburg	$\sigma_{eq} = p\sqrt{\frac{3}{2}}\left[\frac{1}{2}\left(\frac{D}{t}\right) - 0.5\right]$
API-ASME Code 1943—"Average Diameter"	$\sigma_{t,Avg.} = p\left[\frac{1}{2}\left(\frac{D}{t}\right) - 0.5\right]$
Modified Lamé	$\sigma_t = p\left[\frac{1}{2}\left(\frac{D}{t}\right) - 0.4\right]$
Blair	$\sigma_{eq} = p\sqrt{\frac{\left(\frac{D}{d}\right) + \left(\frac{D}{d}\right)^2 + 3 + \left(\frac{D}{d}\right)^4}{2}} \Big/ \left(\frac{D}{d}\right)^2 - 1$

The relative relationship of these wall thickness formulae is shown in Figure 1 as taken from Burrows, Michel, and Rankin.[1]

Blair[3] has summarized the work of several investigators in the field of yielding and bursting of tubes at room temperatures. The Lamé formula as modified by Boardman has found considerable acceptance, and for room and only slightly elevated temperatures is considered acceptable. The Soderberg formula is considered acceptable for average creep stress or inner-bore creep stress evaluation on heavy-walled pipe or tubing.

The ASA Task Force formula was developed to embody as many as reasonable of the features of formulas which would include the prediction of wall thickness under conditions of creep as well as those where only pressure effects would predominate. "At room and slightly elevated temperatures this Task Force formula reduces to the modified Lamé, while at high temperatures it reduces to the creep common formula; the temperature—dependent parameter, y, performs the transition between these two formulas.[1,3] Thus this relation satisfactorily correlates (a) available room temperature tubular bursting data, (b) various creep expressions for high temperature, (c) Soderberg formula involving yielding, creep, and high-temperature rupture, with the common or average stress expression and

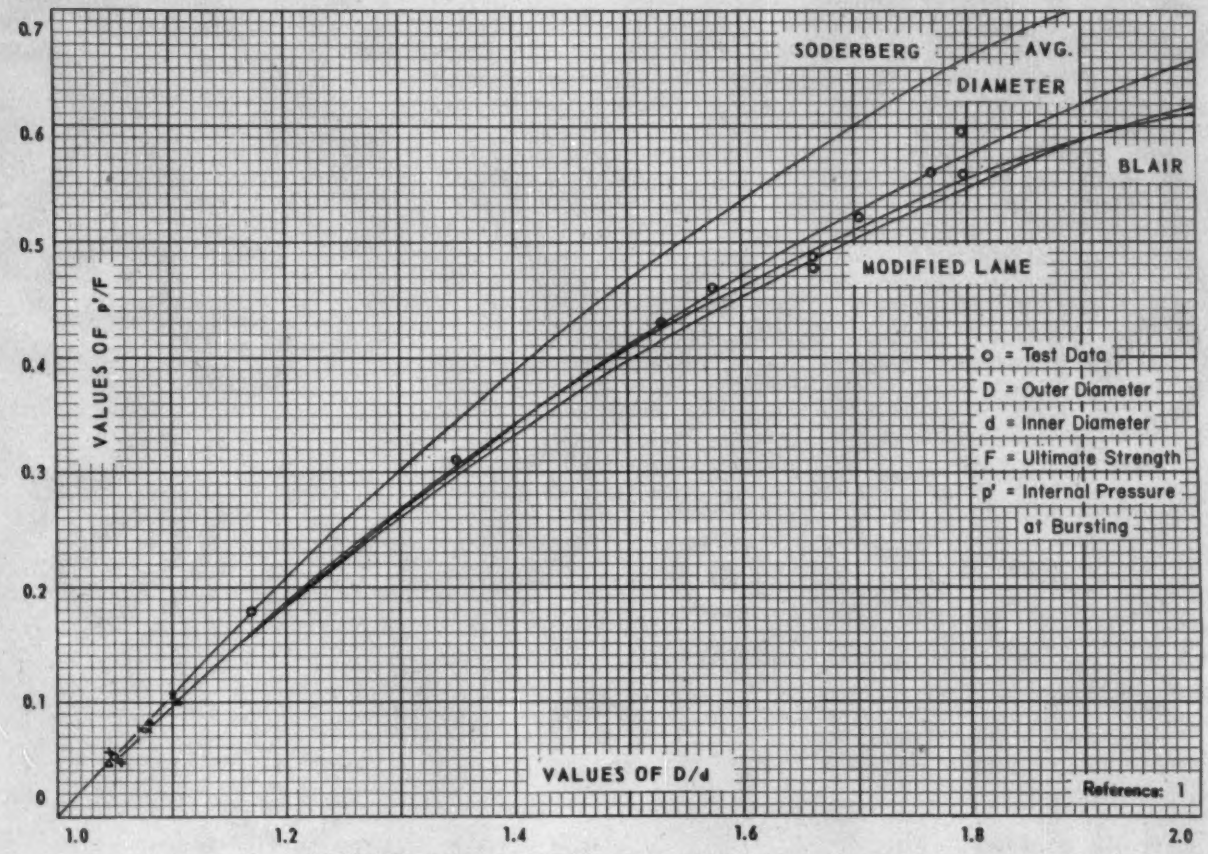

FIGURE 1—Relative relationship of various wall thickness formulae.

modified Lamé formulas for thin-walled pipe and tubes.

As an example of considerations suggested above, see typical calculations in box.

Assembly and Erection

The assembly and erection of high-pressure plants presents problems which are unique by conventional low-pressure methods. Perhaps the most important piping consideration in erecting high-pressure plants is to keep all lengths as short as possible; thereby reducing support and expansion problems and cost of materials.

Large Plants

Commercial production uses both pipe, tubing, and fittings of the pilot plant and also special or custom items which extend the size limits for large flow conditions. Some commercial production can be adequately handled in the size equipment and piping used in other instances for pilot operations.

In the assembly and erection of the larger equipment, despite the use of "high" strength materials, weight is an ever present consideration. For example, 1½-inch standard pipe weighs 2.718 pounds per lineal foot while double extra-heavy weighs 6.408 pounds. In many cases, double extra-heavy rating is insufficient (1.900-inch O.D x 1.100 - inch I.D. x 0.400 - inch wall) and thus the weight increases with wall thickness. Although few processes use pipe larger than 6-inch (6.625-inch O.D.), the double extra-heavy weight is 53.16 pounds per foot.

Dimensionally, this pipe is not usually satisfactory for pressures in the range of 3500 to 30,000 psi. Thus, the weight situation demands close consideration.

1. Fittings may be of many types and descriptions. Systems have been assembled using a variety of specially developed and now proven items for the custom application of high pressure operations. Included in this category are such items as socket-weld, socket-screwed, screwed sleeves, electrical adapters, sample connections, and many other specially designed items to fit the special nature and problems in handling and controlling high pressures. Some items were developed for high-pressure gas and oil field work and have been adapted to process piping systems, and vice versa.

The erection or assembly of the smaller sizes (through 2-inch nominal) uses threaded connections involving various union arrangements. These are similar to those for the small tubing, but larger and modified to suit the fabrication problems of the heavier wall thickness and inside dimensions (referenced to pipe).

Although the union type connection can be used for pressures below 15,000 psi, threaded connections are usually more economical for 3500 to 8000 psi in pipe sizes through 1¼ to 1½-inch. A combination of threads in a union design can be used above this range, if properly handled.

Threaded connections require extreme care in obtaining perfect threads. The "standard" or conventional low-pressure thread (found on commercial fittings) will probably not

be acceptable. Threads on high-pressure threaded connections should be clean, properly tapered (if taper desired), and uniformly cut. This is necessary to insure uniform bearing. The length of threading on pipe or tubing should be carefully considered, since unnecessary exposed threads is poor safety practice.

Straight threads are usually associated with a union or sleeve type connection requiring a gasket. They are reinforced on assembly for essentially their entire cut length. In addition to the American Briggs Standard taper and straight threads, there are several British Standard threads being used, particularly in the pressure range above 12,000 psi. The advantages pointed out for some of these threads is the reduction of sharp edges and notches, thus reducing the possibility of failure due to stress concentration.

Most process companies require the use of separate thread-cutting equipment for high-pressure pipe. This is regularly inspected, and new dies are always available if the quality of the threading becomes questionable. A bit of care here can save time and cost in reducing problems of leaking connections during test.

Lubrication of threads in certain high-pressure services is controversial. Lubrication of tapered threads may be helpful, if the lubricant does not leach or dissolve in the process fluids and helps in later disassembly. Some oil suspensions tend to gum badly, and although the carbon-suspension lubricants have good features, the presence of carbon must be carefully considered. In general, lubricants are of little value on nontapered threads.

2. Bolts for flanged connections require attention in assembly to insure uniform loading on the gasket surface. Uneven loading on assembly can cause serious trouble under internal pressure. Aside from the possible danger to personnel, the leaking of high-pressure gas, liquid, or slurry can cut out flange faces and ruin gasket surfaces and gaskets. Once a high pressure joint is set, it is often difficult to determine if it has been corrected from a poor seating condition without breaking the joint. This is usually at the expense of a gasket and the labor involved.

3. Gaskets—Different experiences have been reported in assembling the lens joint. Often, poor results with this versatile gasket can be traced to hardness greater than 130 Brinnell, non-uniform bolt loading, dirt at the mating surfaces, or poor surface condition on the flange or gasket. Badly scratched surfaces give trouble in operation.

The delta, wave ring, and similar special gaskets have been used successfully in high-pressure piping, although not nearly so frequently as the lens and confined tongue-and-groove gaskets. A "High Pressure" report[10] gives good information on these gaskets when used primarily for vessels; however, special applications have developed (particularly in the field of instrumentation) and been scaled down and redesigned for the smaller diameter service.

Uniform bolt loading techniques vary; some users prefer to gage between flange faces, others prefer the torque wrench, and still others prefer the "calibrated eyeballs" of some experienced person responsible in the erection of this equipment. Some installations have followed high temperature power practice by using bolt elongation as a measure of gasket

WALL THICKNESS BY VARIOUS METHODS

Using ASTM, A-106 Grade B pipe, what is the wall thickness if:

1. Operating pressure = 5,000 psi
2. Test pressure = 8,000 psi
3. No factor of safety to be considered at test pressure.

Use the maximum shear theory of failure of Tresca.[9] Yield point for ASTM, A-106 Grade B pipe = 35,000 psi. According to this theory of failure, yield occurs when the maximum shear stress equals one-half of the yield stress of the same material in simple tension.

Thus:

$$\text{Max } S_s = 1/2\ S_y$$

In order to avoid yielding at 8,000 psi test, use tensile stress at 95 percent of 35,000 psi (= 33,000 psi)

$$\text{Max } S_s = 1/2\ (33{,}000) = 16{,}500 \text{ psi}$$

$$\text{Max } S_s = \frac{p\ D^2}{D^2 - d^2}$$

Then:

$$16{,}500 = \frac{8{,}000\ D^2}{D^2 - d^2}$$

$$d = 0.717\ D$$

For a 6-inch nominal pipe (standard pipe size O.D.), inside diameter would be:

$$d = 0.717\ (6.625) = 4.750 \text{ inches}$$

Thus:

Wall thickness =

$$\frac{6.625 - 4.750}{2} = 0.938 \text{ inch}$$

Assuming we accept this theory of failure, 6-inch pipe could be tested at 8000 psi and not be expected to yield in shear, since we used 95 percent of the allowable yield stress of the material in our original calculations. If 100 percent of the allowable had been used the test would place the pipe at yielding conditions.

Considering this same problem using the ASA Task Force equation:

$$t = \frac{pD}{2S + 2yp}$$

$$= \frac{5{,}000\ (6.625)}{2\ (15{,}000) + 2\ (0.4)\ (5{,}000)}$$

$t = 0.975$ inches wall thickness 6-inch pipe.

Since the allowable stress values from the ASA piping code have a built-in factor of safety, the results obtained by the two methods should be comparable.

Bear in mind that there have been no allowances for corrosion or wall thinning in case the pipe were to be fabricated using shop-made bends.

Assuming an allowance of 0.080 inch for thinning of wall section during fabrication, and 0.040 corrosion allowance, then the example becomes:

Minimum wall thickness (to purchase)

$$= t_{calc.} + t_{bend} + t_{cor}$$
$$= 0.938 + 0.080 + 0.040$$
$$= 1.058 \text{ inches}$$

Say: 1.06 inches

Unless there are other factors which must be considered (such as threading), this wall thickness should be satisfactory; however, a minimum wall thickness should be specified, since an average wall specification with mill tolerances will allow some tubes to be acceptable with wall thickness less than 1.06 inches.

Of course, a minimum wall specification will force all of the tolerance to be toward a small inside diameter, thus giving a smaller bore than the calculated figures for a reasonable portion of the order. The usual wall tolerance is plus or minus 10 percent on cold-drawn tubing; however, each manufacturer should be specifically checked on this point to be certain of the dimensional limitations of the finished product. Of course, these tolerances must be considered independent of the pressure, corrosion, bending, threading, and other process influenced conditions.

loading. This requires the calibration of bolt elongation for each size and length of bolt and for each type and size of joint connection. With care, this insures a very uniform and controlled assembly of gasket connections.

Using torque wrenches to obtain uniform loading also requires a calibration of bolt sizes and length for each joint size and type. Of course, this can be calculated theoretically, but since yielding of gaskets and mating surfaces presents some deviation, the calibration route is preferred. In conjunction with this, bolt elongation must be measured on the "test" joints in order to establish the torque value required to produce the required bolt stress. Once this simulation step has been completed, the torque wrench can be used directly to load the gasket.

Regardless of the scheme selected for flange joint assembly, it is important to tighten uniformly and not prematurely set the gasket. Hand tightening of the nuts is suggested, then gradually tighten opposite nuts on the joint. Do not bring a single nut to full tightness before the others have been carefully stepped up toward this final condition.

In assembling a tongue-and-groove type connection, the same basic considerations apply, except that gasket loading is not quite so critical. The confined gasket changes the conditions but ultimately must be set in a known condition of loading. After some experience, schemes can be developed to indicate to the inspector whether the joint is properly assembled.

4. Welding—Pipe and fitting welding should be under controlled conditions as joint failures are potential hazards. Every welded joint is not necessarily "automatically" perfect and full strength; therefore, inspection of field and shop welding is a must. Standards and limitations should be established for close guidance of this work.

Welders working on high-pressure pipe are usually required to pass the ASME Power Boiler Code Test and any special tests peculiar to the conditions of pipe assembly. Only welders who have passed their tests should perform any high-pressure welding.

The usual practice for carbon steel is the electric arc process for 2-inch pipe and larger (both electric and gas welding, 1½-inch and smaller), preheat the joint assembly to 200 F, and then apply pass after pass using the selected rod with proper removal of slag, etc., as the work progresses. Some installations require inspection of the finished weld, while others require close inspection of the passes as they are laid down. Chipping and grinding may be required to keep the passes clean and sound.

It is wise to give special inspection at this point. Electro-magnetic, fluorescent dyes, and similar aids have been used to check the early welding as well as the finished joint. Often the first three passes are the most critical as cracks can develop here and if not caught will eventually propagate through the finished joint.

The finished weld will usually require stress relief at 1200 F. Shop fabricated sections can be done in a furnace, or in the field using special electrical equipment. In either situation, elbows and bends should be properly braced or controlled with clamps or cable to prevent changing position during the relief operation.

Field stress relief requires more care since each joint must be insulated for the period of heating. Depending upon the thickness of the weld, actual stress relief temperature may be from one hour upwards, but controlled heating and cooling rates, make the over-all period several hours. For carbon steel, stress relief usually begins at wall thickness of ¾-inch and above.

The welding of stainless pipe is even more delicate to handle in order to avoid poor weld conditions. After welding, an 18-8 stainless pipe will be annealed at 1750 to 2000 F. followed by rapid cooling. Each stainless alloy requires separate consideration; therefore, recommendations of a competent metallurgist should be followed. Records are often kept of each weld giving the welder's identification, stress-relief temperature chart, etc.

Process conditions causing thermal expansion into the pipe, require anchors designed to hold unusually high reaction loads and guides arranged to allow these heavy weights of pipe to slide under controlled conditions.

Anchor points should not be against weak structures; in fact, anchoring against any building structure should be undertaken only after the load effects are fully understood. When possible, specially designed and separately situated anchors will give less trouble. The use of concrete should be considered carefully, as a structurally weak anchor may be sheared off or knocked over.

Conventional arrangements may not be adequate for the majority of situations. Anchors usually require welding or otherwise positive attaching to the pipe a rugged well-braced plate which can then be bolted to anchor bolts in concrete, or other structures. The direct welding of the pipe to an anchor is usually avoided, although some situations require this.

Guides on expanding pipe must move unrestricted in the direction of movement, but controlled for any other direction. A guide that binds or grabs in effect becomes an unplanned anchor. Pipe has been torn out of its structure and failures have resulted from such action. This can be extremely hazardous.

Due to the weight factor, guides must be designed for low-bearing loads using materials which do not gall or grab. Materials used include steel, steel on lignum vitae wood, stainless steel on greased carbon steel, and stainless steel on alloys including nonferrous. Real engineering ability is required for proper foolproof control and guidance for the peculiar situations of process piping in high-pressure plants.

5. Testing of high-pressure piping systems prior to operations is a "must." Even though the most meticulous care has been exercised by all associated with the project, this is still no assurance that the variety of unknown factors in metal handling are all under control. Thus a "proof" test must be made to carefully examine each section and assembly. Some parts may have been tested in the shop, but field erected testing is still required. Stresses and strains imposed by assembly must be tested. Field and shop stress relieving is not necessarily sufficient to guarantee how the stresses will act under load conditions.

Of the two types of tests, air and hydrostatic, only liquid filled hydrostatic should be used in testing high pressure pipe for initial proof conditions. The usual practice is to test a section of the whole system, rather

than to fill everything and have high pressure "all around." By blanking off portions of the system, confined areas may be examined safely and effectively. Although practice varies, the pressure is held at least one hour to give some chance for the effect of the pressure condition to be distributed in the system and to allow any leaks or faults to break through. In some installations, the practice is to bring the system up to required test pressures two or more times, each time dropping the pressure to at least half of the test.

Testing with air or other safe gas is somotimes necessary to insure a "bubble"-tight system. The pressure used is 15-50 psig, and it follows only a satisfactory hydrostatic test of the system. Usually soap suds are used to test the joints, welds, threads, etc., for leaks.

Everyone in industry is more or less safety minded. Individual company policy determines how safety is handled and considered. High-pressure piping testing must be planned by safety conscious individuals. Plans are set forth and identified to all concerned, and each individual's responsibility made clear.

Usually the area of test is isolated and made "off-limits" to those not familiar with the activities. All parts holding test pressure are confined to the test area, including the test pump. The test pump operator is protected by sand bags, concrete, steel, or some other arrangement; likewise, the inspectors are protected while the pressure is rising, during the holding of pressure, and while pressure is being lowered.

Mirrors are used to allow inspection behind protective enclosures, and portable shields of stainless afford reasonable protection. Safe inspection is difficult, since a seeping leak may not allow enough pressure loss on the indicator gage to be detected without unusually long intervals of time. To reduce holding time, close personal inspection is necessary. Even with barricades, heavy safety glass face shields are recommended.

A few plants hammer test the pipe, but this practice can be extremely dangerous unless all precautions are taken to protect personnel and equipment. Under hammer test a somewhat otherwise harmless fault can become a major fracture or rupture. An unprotected, exposed person could be in serious danger. Some operating situations warrant this treatment, but it should be undertaken with the utmost care in planning for the safety of all concerned.

Due to the peculiarity of some gasket and joint connections, the system may be tight at low pressure, leaking at operating pressure, and tight at test pressure. In other words, the test could pass through a leaking condition on up to a tight condition and still not be satisfactory for an operating plant. Therefore, close observation is made of the connections, welds valve packings, etc., at selected pressure steps in the testing operation.

Repairs or adjustments may have to be made to satisfy tightness at the operating pressure before the test can be completed. Under no circumstances are welds made, packings tightened, etc., while high pressure is being applied to the test system. Instead, the pressure is reduced to essentially atmospheric for the sake of safety. This feature of high-pressure operations increases labor costs.

There are undoubtedly some who have had experiences which question this somewhat conservative approach. But there are known situations where a man was killed by a jet-like liquid leak from a 5000 psi system, and another where an eye was lost from high-pressure water at 1500 psi due to a faulty weld. These are but two; however, they are not all and even in themselves are sobering and worth the lesson of safety and respect for high-pressure systems. Handling of high pressure is not a matter of chance or luck, and everything associated with the system must be considered a potential safety hazard and protection provided or considered accordingly.

This brief summary is by no means complete; in fact, it is difficult to cover a subject so large and detailed in this short space. There are myriads of details which must be traced to a definite and satisfactory completion—planning, engineering, design, construction, testing, and finally, operations of piping systems where high pressures are performed. Often these details must be cleared in the proper sequence. Many more records must be made and kept, if profitable experience is to be gained from the plant design and operation. It is the collective magnitude of these special problems that gives high-pressure piping technology its uniqueness.

NOMENCLATURE

t = Pipe wall thickness, inches
p = Internal pressure, psi
D = Outer diameter, inches
d = Inner diameter, inches
S = Code allowable stress, psi
y = Parameter with respect to temperature, for ASA Task Force equation
∂_{eq} = Equivalent stress, psi
∂t_{Avg} = Average tangential stress, psi
∂_t = Tangential stress in cylinder, psi
S_s = Shear stress, psi
S_{yp} = Yield stress of material, psi
t_{calc} = Minimum wall thickness calculated, inches
t_{bend} = Wall thickness allowance for thinning at bends, inches
t_{cor} = Wall thickness allowance for corrosion, inches

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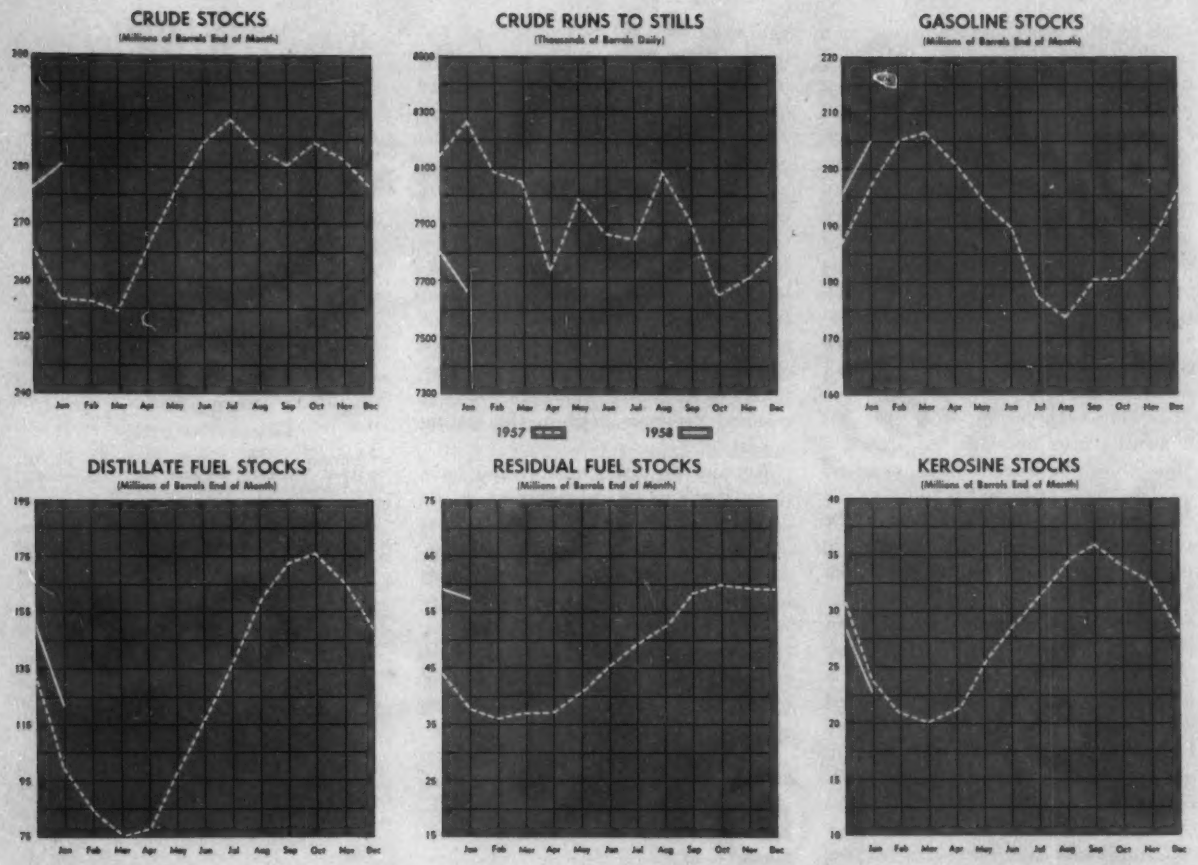
About the Author

Ernest E. Ludwig is process design manager for Dow Chemical Co. at Freeport, Texas. With the company since 1942, he started as a design engineer and was later promoted to section leader. In 1946 he was named manager of Dow's engineering office in Houston. The following year he returned to Freeport as assistant engineering manager, and in 1953 was promoted to his present position. At Dow, he supervises chemical engineering design and rating of both organic and inorganic processes and equipment. Registered on Texas both as a chemical and mechanical engineer, Ludwig is a graduate of the University of Texas where he received B.S. and M.S. degrees in chemical engineering.



Taking Stock

- Gasoline Stocks At All-Time High
- Kerosine Stocks Lowest Since April
- Fuel Oil Inventories Dip Sharply

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	299	18,227	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	292	21,883	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	290	26,111	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	296	28,990	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	313	31,826	1,839	137,905	1,091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	329	33,588	1,845	150,411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	356	35,667	1,772	158,871	1,082	48,400	1,004	1,541
November	7,189	8,031	275,995	3,913	174,808	384	34,329	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	379	31,420	1,981	133,981	1,288	44,491	873	1,471
1957:													
January	7,480	8,274	256,669	3,991	197,702	367	24,019	2,118	100,572	1,322	38,403	805	1,425
February	7,682	8,088	256,344	3,864	205,270	353	21,013	2,035	85,105	1,270	31,201	780	1,430
March	7,717	8,047	254,911	3,826	206,716	332	20,223	1,861	76,245	1,205	37,371	836	1,464
April	7,541	7,740	265,796	3,770	201,407	284	21,512	1,764	78,743	1,132	37,429	906	1,542
May	7,442	7,992	275,963	3,900	195,094	272	25,545	1,789	98,135	1,103	41,125	1,042	1,558
June	7,107	7,867	284,312	3,984	190,063	254	28,872	1,773	117,364	1,101	45,572	1,147	1,606
July	6,873	7,852	288,241	3,887	177,868	249	31,713	1,750	138,359	1,090	49,621	1,220	1,654
August	6,786	8,092	283,388	4,122	174,031	252	34,576	1,806	159,124	1,089	52,645	1,257	1,695
September	6,887	7,920	280,469	4,099	180,688	276	36,382	1,772	173,269	1,100	58,727	1,042	1,445
October	6,860	7,650	284,517	3,939	180,902	265	34,384	1,705	176,388	1,052	60,025	1,022	1,532
November	6,824	7,692	281,769	3,901	187,141	324	32,696	1,734	166,763	1,069	59,622	902	1,455
December	6,895	7,803	276,561	3,935	196,377	315	28,615	1,874	150,769	1,111	59,315	1,045	1,619
1958:													
January	6,883	7,661	280,601	3,832	205,057	362	22,951	1,855	122,325	1,067	57,520	955	1,550
Week Ended:													
2-21-58	6,808	7,506	*284,759	3,705	213,659	338	18,596	1,715	96,668	1,110	55,435	558	1,080
2-22-57	7,567	7,795	*251,684	3,668	204,122	331	21,723	1,980	87,738	1,236	35,772	832	1,437

*Data are for one week earlier.

Source: Data, for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

New Agitator Absorber for CO_2

Four factors were tested at three levels and an equation developed for directly calculating the operating conditions.

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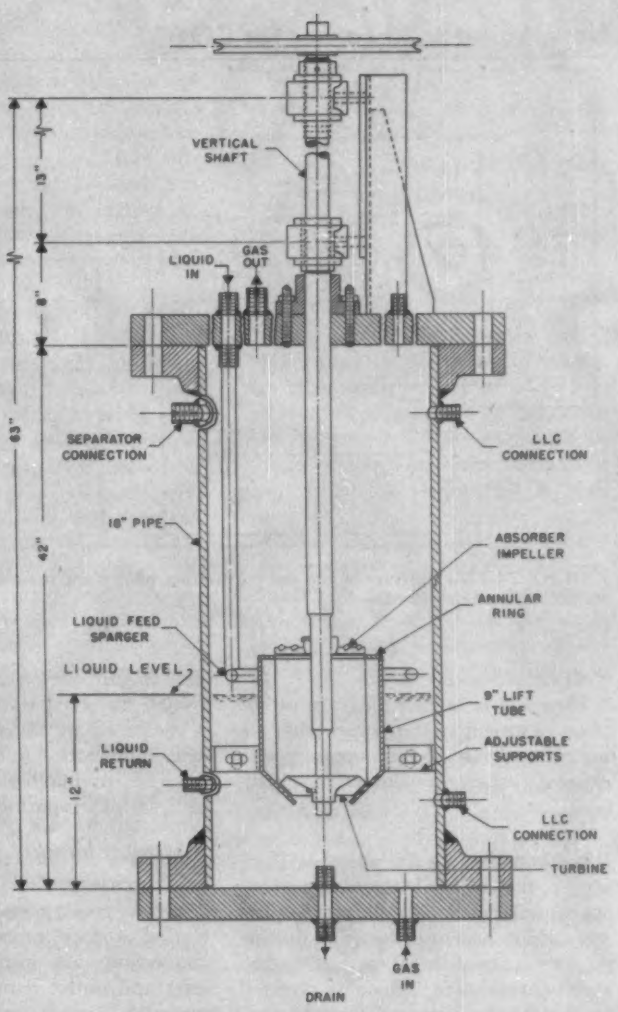


FIGURE 1—A vertical cross-section of the agitator absorber. The turbine provides a spray curtain through which the gas flows upward.

A STATISTICAL investigation on an agitator absorber for removing CO_2 from gases has proved it to be an effective gas-contacting mechanism. An empirical performance equation, using the factors tested, has been developed. Operating conditions may be calculated directly from this equation.

During the last fifteen years, processes for removing carbon dioxide and hydrogen sulfide from industrial gases by scrubbing with various amines have become generally accepted. To date, these processes have employed conventional gas-liquid contactors, packed columns and bubble-cap towers.

The absorptive capacities of the amines increase markedly with increased concentration,[3] but operating difficulties in conventional scrubbers using process liquids of even moderate viscosity, have limited concentration to about 15 percent amine in water. Thus, for these processes to realize full commercialization, methods of gas-liquid contacting able to tolerate more viscous scrubbing media must be developed.

Studies were made using an agitator-type contactor for the absorption of carbon dioxide in 40 weight-percent diethanolamine in water. Figure 1 shows a vertical cross section of the absorber. The action within the absorber is as follows: The lean solution is fed into the vessel through a sparger ring. The liquid is raised in the lift tube by the centrifugal action of the turbine and propelled from the absorber impeller in the form of a fine spray. This spray of liquid droplets moves at a high speed relative to the gas stream which passes through the spray curtain in upward flow through the absorber. Inasmuch as this is a relatively novel gas-liquid contactor, it is to be expected that its mode of action would be distinctive.

These studies were undertaken to determine the characteristics of the agitator-absorber with respect to:

1. Process pressure.

2. Carbon dioxide content of the feed gas.

3. Absorbent solution rate, and

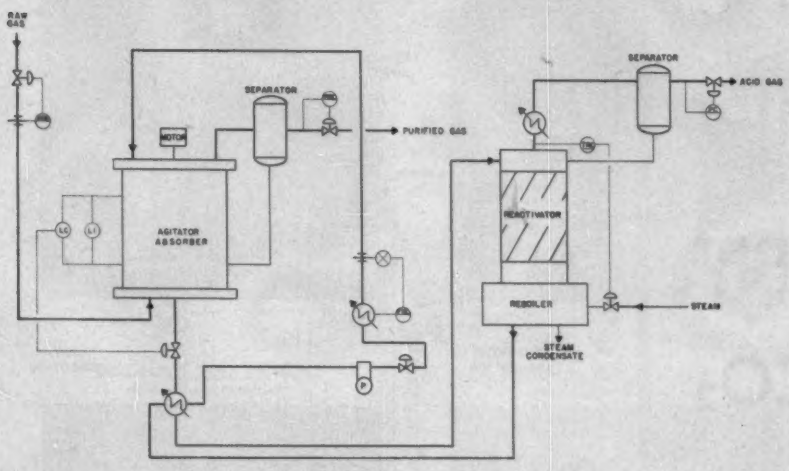


FIGURE 2—Flow diagram of the gas purification pilot plant showing the absorber and amine purification system.

4. Liquid-to-gas ratio.

Figure 2 is a flow diagram of the pilot plant. For this study the absorber was installed to operate with existing solution-regeneration facilities.

The Absorber. In the absorber (Figure 1), the essential internal parts are the annular ring and lift tube and the turbine and impeller. The turbine imparts a centrifugal action to the absorbent solution, which is directed by the annular ring and lift tube onto the impeller, where the spray is formed. The latticed faces of the impeller are beveled to about 38 degrees off horizontal so that the principal portion of the spray is directed toward the walls of the absorber vessel rather than the top. A 1-hp motor (1750 rpm) connected to the shaft through sheave pulleys is used to drive the turbine. A constant turbine speed of 750 rpm was used for these tests.

The Reactivator. The reactivator tower is a 17-foot length of 10-inch, schedule 40 pipe, which is packed to a depth of 15 feet with ¾-inch Raschig rings and direct-connected to the reboiler by 10-inch diameter flanges. The reboiler is 10 feet in length and 16 inches in diameter. It is fitted with a pressure connection, connections for adding make-up condensate and for draining the solution, and a thermocouple connection installed near the end of the tube bundle. Steam for reactivation is controlled by a pressure controller and is measured by weighing the condensate. The entire unit is lagged with 2 inches of magnesia insulation and ¼ inch of insulating cement.

Auxiliary Equipment. The solution heat exchanger, solution cooler, and acid-gas cooler are all similar extended surface units. Thermocouple connections are installed so that all inlet and outlet temperatures can be recorded.

A 1¼ by 4-inch triplex, single-acting power pump circulates the solution. The flow of the solution to the absorber is controlled by an air-operated bypass valve.

The gas is stored, before compression, in a wet-type gas holder having a capacity of 1000 cubic feet. The two-stage gas compressor can deliver 7200 standard cubic feet per hour at 350 psig.

Solution and Gas Flow. The flow of solution and gas in the pilot plant is typical of most gas-purification systems. Inert gas, varying in CO_2 content from 7 to 10 mol-percent, is taken from the gas holder, compressed to about 350 psig, and fed to the absorber. The carbon dioxide necessary to bring the carbon dioxide content of the unpurified gas to the level of predetermined experimental conditions is added to the suction line of the compressor.

The lean diethanolamine solution enters through the top of the absorber. It is distributed by a sparger ring directly above the liquid level and just below the top of the lift tube and leaves the absorber through a side connection six inches from the bottom. The level of solution in the absorber is maintained to a depth of 12 inches (indicated by the broken line in Figure 1). The diethanolamine is forced up into the lift tube by the turbine; baffles in the lift tube eliminate any swirling action. The rising solution contacts the absorber impeller, a deflector designed to give maximum spray commensurate with the dimensions of the absorber vessel. Three distinct spray patterns are formed:

1. The initial spray from the absorber impeller, consisting of small droplets moving at very high velocities.

2. Impact spray formed when the initial spray rebounds from the walls of the vessel.

3. Conjunctive spray formed when the initial spray and impact spray collide.

The feed gas enters at the base of the absorber to the right of the lift tube. It bubbles through the diethanolamine, passes through the spray pattern, and leaves the top of the absorber into an entrainment separator as purified gas. It is then returned to the gasholder for feed-gas make-up.

The fouled amine solution leaving the bottom of the absorber is heated by heat exchange with lean amine solution and regenerated in the reactivator with indirect heat from low-pressure steam. The acid gas leaves the top of the reactivator and passes through a cooler where entrained steam is condensed and returned to the column. The acid gas is then returned to the holder for feed-gas make-up.

The reactivated diethanolamine leaves the reactivator, flows through the heat exchanger where it gives up a portion of its heat to the fouled solution leaving the absorber, and is pumped through a water-cooled solution cooler back to the absorber.

EXPERIMENTAL PROCEDURE

The agitator gas-liquid contactor

is a novel piece of equipment. To evaluate it in terms of more conventional gas-cleaning apparatus, packed columns and bubble-cap towers, optimum operating conditions for the agitator absorber process must first be found.

Factors affecting absorber performance are:

1. Process pressure.

2. Carbon dioxide content of the feed gas

3. Absorbent-solution throughput

4. Liquid-to-gas ratio

5. Concentration of the absorbent solution

6. Temperature of the absorbent in the absorber.

7. The speed of the turbine and

8. Carbon dioxide content of the lean absorbent solution.

Although the operational levels of all of these factors are easily controlled within relatively narrow limits, there is no reason to suppose that the efficiency of the process is an additive function of any two of them. Consequently, the complete exploration of the causal relations among these factors would require that the effect of each factor be observed under all combinations of values of the other factors. Such a procedure would require a relatively large number of tests.

To overcome this difficulty, a series of sequential factorial experiments, each concerned with a group of relevant factors, was initiated. Such a procedure allows for maximum flexibility in planning and has the inherent advantage that, as each factorial is developed, the factors involved may be directed toward optimum conditions relevant to all other factors.

Process pressure (200-300 psig), carbon dioxide content of the feed gas (10-20 mol-percent), absorbent solution throughput, (60-90 gph) and liquid-to-gas ratio (16.4-55) were chosen as the independent variables for the initial experiment. Liquid-to-gas ratio is defined as gallons of solution per 1,000 scf. of feed gas per hour. The dependent variable in the process is the total carbon dioxide absorbed, since all other variables for these experiments were predetermined.

As dictated by subsequent operation, a second factorial was designed at new operational levels for the four factors. The purpose of the second set of experiments was to investigate further the interactions among the various factors revealed in the initial set of tests. The block design for each factorial is presented in Appendix 1.

DATA AND RESULTS

Table 1 presents typical operating conditions prevalent throughout the 30 tests performed for this study; Table 2 presents the cumulative data from these tests.

TABLE 1
Typical Operating Range for All Runs

Gas Temperature, F	
Before agitator	75–85
After agitator	140–155
Solution Temperature, F	
Before agitator	100–110
After agitator	140–160
Reboiler pressure, psig	6.5—8
Reboiler temperature, F	265–275
Agitator Motor	
Ammeter, amps	1.2—1.4
Voltmeter, volts	470 (constant)
Steam pressure, psig	22–30
Steam consumption, lb./gal. amine	0.6—0.8
Turbine speed, rpm	750 (constant)

A statistical analysis of the data from experiment "A" is made and an analysis of the cumulative data from experiments "A" and "B" is presented.

An empirical equation relating the independent variables to the performance of the agitator absorber is developed. The effect of the same variables on the performance of the agitator is presented graphically in Figure 3.

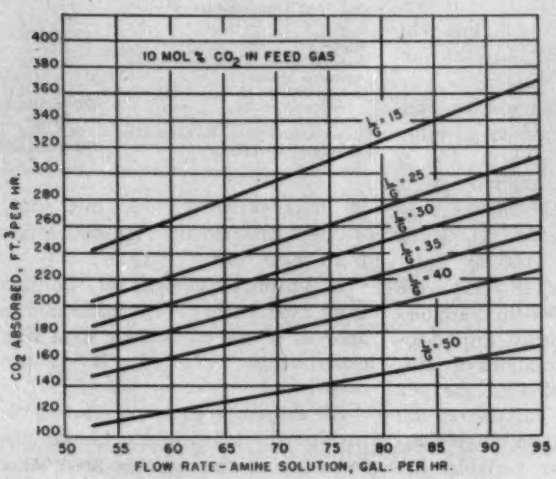
EVALUATION OF DATA

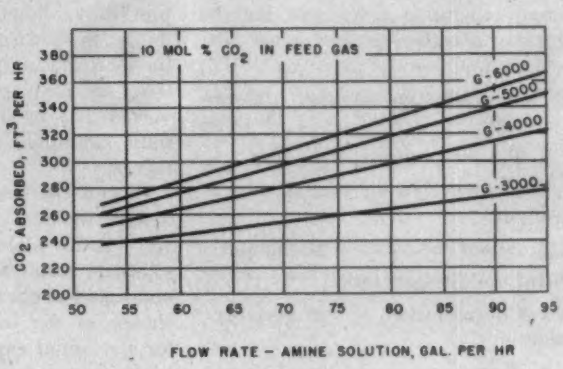
Table 2 presents an analysis for significance of the 16 runs of experiment A in which the factors involved were tested at the high and low levels. This analysis was made using the method of Yates.[5]

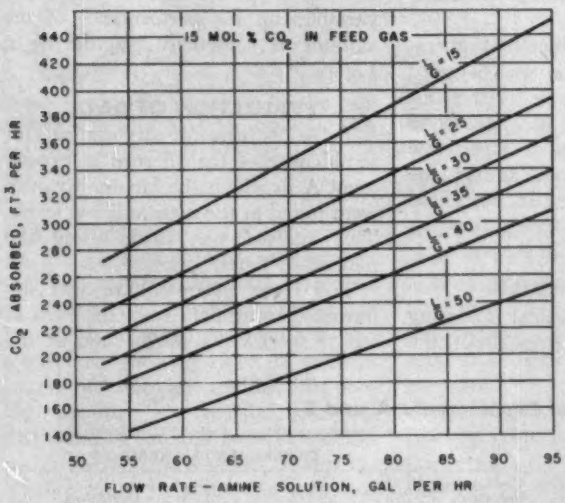
The error mean square was determined using data from the runs at which the factors were tested at the

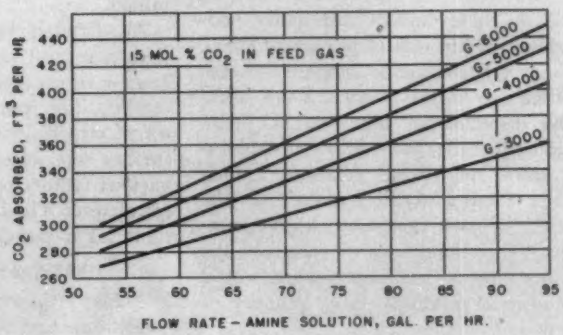
TABLE 2—Data From Factorial Experiments A and B

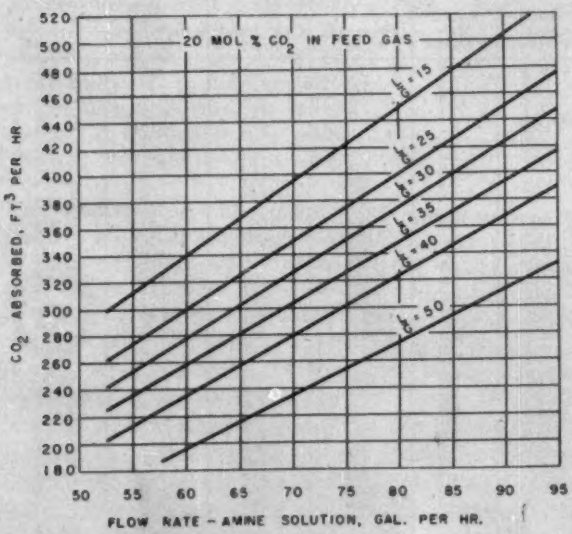
	EXPERIMENTAL CONDITIONS							EXPERIMENTAL RESULTS			
						CO_2 Content-Gas Streams		CO_2 Absorbed		Deviation Observed from Calculated	
Run No.	P psig	C Mol-Percent	S Gal./Hr.	L/G gph Solution 1000 scfh Gas	G scfh	Rich, Mol-Percent	Lean, Mol-Percent	Observed, cf/Hr.	Calculated, cf/Hr.	cf/Hr.	Percent
A-1	300	20.2	90	16.4	5500	20.2	11.8	515	499	—16	— 3.1
A-2	300	10.2	90	55	1640	10.2	0.9	155	137	—18	—11.6
A-3	200	20.2	60	16.4	3650	20.2	11.9	350	339	—11	— 3.1
A-4	200	10.2	60	55	1045	10.2	1.1	96	101	+ 5	+ 5.2
A-5	250	15.2	75	35.7	2100	15.2	3.2	263	273	+10	+ 3.8
A-6	300	20.2	60	55	1045	20.2	0.95	201	181	—20	—10.0
A-7	200	20.2	90	55	1640	20.2	2.3	303	280	—23	— 7.6
A-8	250	15.2	75	35.7	2100	15.2	2.8	270	272	+ 2	+ 0.7
A-9	300	10.2	60	16.4	3650	10.2	3.4	260	262	+ 2	+ 0.8
A-10	200	10.2	90	16.4	5500	10.2	3.6	373	349	—24	— 6.4
A-11	200	10.2	60	16.4	3650	10.2	2.5	296	264	—32	—10.8
A-12	250	15.2	75	35.7	2100	15.2	2.5	271	267	— 4	— 1.5
A-13	200	10.2	90	55	1640	10.2	2.3	132	141	+ 9	+ 6.8
A-14	200	20.2	60	55	1045	20.2	2.6	189	177	—12	— 6.3
A-15	300	10.2	60	55	1045	10.2	1.3	91	102	+ 9	+10.0
A-16	300	10.2	90	16.4	5500	10.2	3.9	342	343	+ 1	+ 0.3
A-17	300	20.2	90	55	1640	20.2	2.6	294	295	+ 1	+ 0.3
A-18	300	20.2	60	16.4	3650	20.2	12.5	309	334	+25	+ 8.1
A-19	200	20.2	90	16.4	5500	20.2	12.3	496	503	+ 7	+ 1.4
A-20	250	15.2	75	35.7	2100	15.2	2.8	275	277	+ 2	+ 0.7
B-1	250	22.4	75	35.7	2100	22.4	8.0	329	351	+22	+ 6.7
B-2	250	15.2	96.2	35.7	2700	15.2	3.5	325	339	+14	+ 4.3
B-3	250	15.2	53.8	35.7	1500	15.2	2.9	188	196	+ 8	+ 4.3
B-4	250	15.2	75	58.8	1200	15.2	2.1	166	156	—10	— 6.0
B-5	250	15.2	75	35.7	2100	15.2	3.4	261	267	+ 6	+ 2.3
B-6	179	15.2	75	35.7	2100	15.2	3.3	269	267	— 2	— 0.7
B-7	250	8.0	75	35.7	2100	8.0	1.0	149	187	+38	+25.5
B-8	250	15.2	75	12.6	5950	15.2	10.2	327	378	+51	+15.6
B-9	321	15.2	75	35.7	2100	15.2	3.0	262	267	+ 5	+ 1.9
B-10	250	15.2	75	35.7	2100	15.2	3.0	262	267	+ 5	+ 1.9
Average	....	....	....	....	....	....	....	.....	....	±13	± 5.6











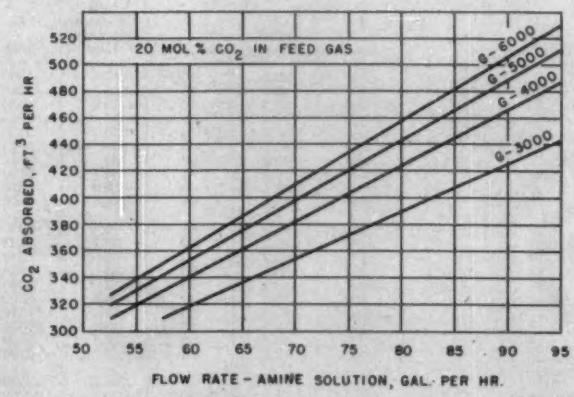


FIGURE 3—An expression of the scrubbing capacity of the agitator absorber as a function of solution through-put and CO_2 content of feed gas with L/G ratios and gas rates as parameters. G = Gas rate, standard cubic feet per hour; L/G = Ratio of solution through-put, gallons per hour to gas rate, standard cubic feet per hour.

TABLE 3—Factorial Analysis—Experiment A

P	C	S	L	Run	Y	Factor	$D^2/16$	Significance
-1	-1	-1	-1	A-11	296	Total	1,211,100	....
-1	-1	-1	1	A-4	96	L/G	136,900	0.001
-1	-1	1	-1	A-10	373	S	41,820	0.001
-1	-1	1	1	A-13	132	S L/G	2,601	0.05
-1	1	-1	-1	A-3	350	C	51,984	0.001
-1	1	-1	1	A-14	189	CL	812	nil
-1	1	1	-1	A-19	496	CS	5,625	0.01
-1	1	1	1	A-7	303	CSL	462	nil
1	-1	-1	-1	A-9	260	P	289	nil
1	-1	-1	1	A-15	91	PL	756	nil
1	-1	1	-1	A-16	342	PS	324	nil
1	-1	1	1	A-2	155	PSL	210	nil
1	1	-1	-1	A-18	309	PC	56	nil
1	1	-1	1	A-6	201	PCL	225	nil
1	1	1	-1	A-1	515	PCS	2	nil
1	1	1	1	A-17	294	PCSL	676	nil
0	0	0	0	A-5	263	....	1,453,842	....
0	0	0	0	A-8	270	....	1,211,100	....
0	0	0	0	A-12	271	....	242,742	....
0	0	0	0	A-20	275	....	.....	....

TABLE 4
Empirically Determined Coefficients

Factor	Coded Coefficient
Constant	267.3
C	+57.0
S	+57.125
L/G	−92.5
S L/G	−12.75
CS	+18.75

median levels. The calculation was made using this relationship:

$$\text{E. M. S.} = \frac{\Sigma Y^2 - \frac{(\Sigma Y)^2}{n}}{n-1} = 33.2$$

The standard deviation by definition is the square root of the error mean square. In this instance the standard deviation was ± 6 cubic feet per hour of CO_2 absorbed.

The interactions between the carbon dioxide content and solution throughput, and between the carbon dioxide content and liquid-to-gas ratio revealed in the analysis of the data from experiment A, were evaluated further by solving the normal equations using matrices set up from the cumulative data of experiments A and B. Using the methods of Davies,[2] the coefficients of Table 4 were determined and an empirical equation relating the significant factors to the dependent variable was set up.

By substituting the following real for the above coded factors:

$$P = \frac{P - 250}{50}$$

$$C = \frac{C - 15.2}{5}$$

$$S = \frac{S - 75}{15}$$

$$L = \frac{L/G - 35.7}{19.3}$$

and by affixing the respective coefficients and reducing, equation (1) resulted

$$Y = 178.3 - 7.35\,C + 1.18\,S - 1.49\,L - 0.044\,SL + 0.25\,CS \quad (1)$$

An analysis for variance was made by solving the inverted matrix set up from the cumulative data of experiments A and B, again using the methods of Davies.[2] This revealed that the empirical equation would account for 98.5 percent of the total sum of squares of the dependent variable.

A further analysis for significance was made using Student's "T" test as presented by Villars.[4] By this calculation, the empirical equation contains only those terms significant at less than the five percent level.

The comparison of observed and calculated values for the rate of adsorption of CO_2 in the agitator absorber, included in Table 2, was made employing equation (1).

Figure 3 presents graphically the absorbing capacity of the agitator as a function of solution throughput and CO_2 content of feed gas with gas rates and liquid-to-gas ratios as parameters. The data for plotting (Figure 3) was evolved by solving equation (1).

DISCUSSION OF RESULTS

The dependent variable for these experiments was taken as total carbon dioxide absorbed per hour. The effect of the independent variables—pressure, carbon dioxide content of the feed gas, solution throughput, and liquid-to-gas ratio on the performance of the agitator absorber was determined on that basis.

Significant Effects. The factors of these experiments are tabulated in the fourth column of Table 3. The coefficients that give these factors quantitative meaning are tabulated in Table 4. Examination of these tables shows that the performance of the agitator absorber will appreciate with

Higher solution throughput

- Higher CO_2 content in the feed gas and
- Lower liquid-to-gas ratios.

The effect of these factors and of the interactions among them on the performance of the agitator absorber is given explicit quantitative meaning in the correlation afforded by equation (1). Using this equation the performance of the agitator, in terms of cubic feet per hour of carbon dioxide absorbed, can be predicted to an accuracy of plus or minus 13 cubic feet per hour within the range of these tests.

Operating requirements commensurate with feed gas composition may be observed directly by reference to Figure 3.

Comparison With Conventional Scrubbers. Using the methods of Coulson and Richardson,[1] the overall mass-transfer coefficients for the agitator absorber were calculated at three sets of conditions, runs A-1, A-2, and A-12.

Until strict criteria for the choice of agitator volume are resolved, it is not possible to make a generalized comparison of the performance of the agitator absorber with conventional scrubbers on the basis of overall mass-transfer coefficients. The principle of operation, and hence the flow mechanics in the two systems, are quite different; indeed, the flow mechanics in the agitator are extremely complex. However, it is possible to

TABLE 5—Data for Comparing Agitator Absorber to Packed Tower

Run No.	KgA*	Packing	Cross Tower Section, Sq. Ft.	Packing Height, Ft.
A-1	0.227	¾ Raschig rings	0.5	5
A-2	.262	¾ Raschig rings	.5	6
A-12	.111	¾ Raschig rings	.5	10

* KgA for agitator absorber = $\frac{\text{lb:mol of } CO_2 \text{ absorbed}}{\text{(hr.) (atm. } CO_2 \text{ partial pressure) (Cu. ft. solution)}}$

Appendix I

The Block Design For Factorial Experiments A And B

Factorial Experiment A								Factorial Experiment B			
Set I				Set II							
A	B	C	D	A	B	C	D	A	B	C	D
-1	-1	-1	-1	1	-1	-1	-1	0	0	0	1.2
-1	-1	-1	1	1	-1	-1	1	0	0	0	-1.2
-1	-1	1	-1	1	-1	1	-1	0	0	$\sqrt{2}$	0
-1	-1	1	1	1	-1	1	1	0	0	$-\sqrt{2}$	0
-1	1	-1	-1	1	1	-1	-1	0	$\sqrt{2}$	0	0
-1	1	-1	1	1	1	-1	1	0	$-\sqrt{2}$	0	0
-1	1	1	-1	1	1	1	-1	$\sqrt{2}$	0	0	0
-1	1	1	1	1	1	1	1	$-\sqrt{2}$	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

In which

	LEVELS				
	Factorial A			Factorial B	
	Interactions			Curved Effects	
	High	Medium	Low	High	Low
A = pressure, p.s.i.g.	300	250	200	321	179
B = CO_2 content of foul gas, mol percent	20	15	10	22.4	8
C = solution throughput, gal./hr.	90	75	60	96.2	53.8
D = liquid-to-gas ratio, gal./1000 s.c.f.h.	55	35.7	16.4	58.8	12.6

The level designations: 1, —1, 0, $\sqrt{2}$, $-\sqrt{2}$, 1.2, and —1.2 may be defined as the value of the variable in question minus the mean value of that variable divided by the interval for that variable. The interval in turn may be defined as the value of the variable designated as 1 minus the value of that variable designated as 0.

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compare the performance of the two types of equipment for specific operating conditions and to describe the performance of the agitator in terms of a physical tower required to effect the same degree of scrubbing at those operating conditions. This comparison has been made and is presented in Table 5. It shows the size towers that would have to be employed in place of the agitator absorber for the specified runs.

Cubic feet of solution is taken as that volume of the absorber actually occupied by solution, irrespective of the spray. For these calculations, that volume was considered to be a cylinder 18 inches in diameter by 12 inches in height. The actual absorber has a cross section of 1.42 square feet and an inside height of 3.5 feet.

For Further Study. It has been shown[3] that the performance of an absorber of centrifugal design is greatly affected by the characteristics of the spray pattern it develops. The spray pattern in turn is almost totally a function of the turbine design and speed, the impeller design, and the viscosity of the absorbent. The viscosity of the absorbent is dependent on the concentration and temperature of the diethanolamine in the absorber. Consequently, this factorial will be expanded to include the factors: (1) turbine speed, (2) concentration of absorbent, and (3) temperature of the absorbent in the absorber.

NOMENCLATURE

Y = total CO_2 absorbed, cubic feet per hour

L = L/G = liquid-to-gas ratio, $\frac{\text{gallons per hour solution}}{\text{1,000 std. cu. ft. gas per hr.}}$

S = solution throughput, gallons per hour

C = CO_2 content of feed gas, mol percent

P = process pressure, psig

$D^2/16$ = sum of the squares of the dependent variable accounted for by a given factor, divided by the number of tests involved.

n = number of tests contingent to a given calculation.

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Newest Acetylene Process from Japan

Operating at 1200-1250 C and at reduced pressure this new process gives good yields of acetylene from C_1-C_4 hydrocarbons.

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A NEW PROCESS for the production of acetylene from gaseous hydrocarbons in the methane to butane range has been developed. The process uses low oxygen to hydrocarbon ratios and operates at 1200-1250 C under reduced pressures.

Excellent yields of acetylene have been obtained being as high as 50 percent using oxygen-methane ratios of about 0.2-0.5. The reaction can be carried out using silica as a catalyst but proceeds well without any catalyst. Hydrogen is used to prevent coking when using the higher hydrocarbons. Industrial applications are now under study.

The Sachsse[1] acetylene process produces a mixture of acetylene, carbon monoxide and hydrogen by the partial oxidation of methane, using a specially designed burner type reactor. Acetylene yield is about 1/8-1/10 the volume of carbon monoxide-hydrogen mixture produced. Thus, acetylene could be considered a by-product in this process.

This new acteylene process using gaseous hydrocarbons, produces acetylene as the main product. C_1-C_4 gaseous hydrocarbons were reacted with various amounts of oxygen at about 1200-1250 C under reduced pressure of 6-60 mm Hg in the presence and absence of a catalyst.

This process uses optional amounts of oxygen for methane and with smaller amounts of oxygen, acetylene becomes the main product.

As raw materials, C_2-C_4 olefins and paraffins have been successfully used instead of methane. A catalyst was preferable for methane, but when C_2-C_4 hydrocarbons were used, the results were similar with or without a catalyst.

Acetylene from Methane or Methane-Hydrogen Mixture. Research was started to produce acetylene from the methane-hydrogen tail gas remaining after removing olefins from the cracked gas obtained in the Tsutsumi Vacuum Cracking process.[2]

Basic research in the production of acetylene was first started using pure methane.

Effect of oxygen-methane ratio. The ratio of oxygen to methane was varied from 0.17 to 0.77 and the mixtures were passed over 5-10 grams of granulated silica maintained at 1250 C, at the rate of 100 liters per hour under a reduced pressure of 6-60 mm Hg. These results are shown in Figure 1.

The acetylene content in the reaction gas was highest, (10.4 percent) when the ratio was about 0.2, and decreased with an increase of the ratio. As seen from Figure 1, the yield of acetylene from methane feed was a maximum of 36 percent at a ratio of 0.25. However, if the yield is based only on the methane reacted, a maximum yield of 50 percent is reached at a ratio of 0.2.

Figure 2 shows the variation of hydrogen, carbon monoxide and methane content in the reaction gases in relation to the oxygen-methane ratio.

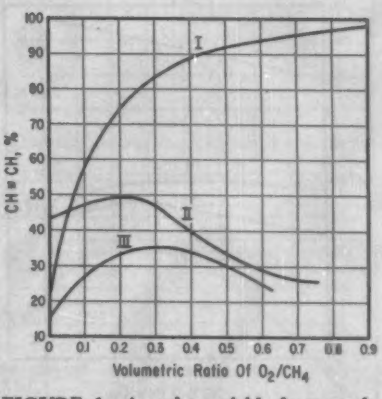

FIGURE 1—Acetylene yields from methane with various oxygen-methane ratios. I. Percent conversion of methane; II. Yield of acetylene from reacted methane; III. Yield of acetylene from raw methane.

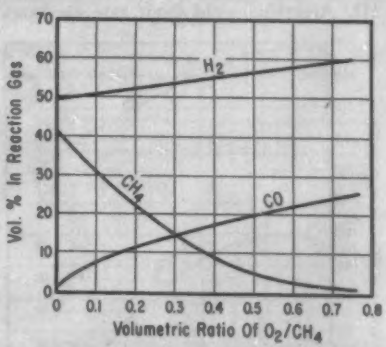

FIGURE 2—Percentage change of hydrogen, carbon monoxide and methane in the reaction gas with changing oxygen-methane ratios.

The percentage conversion of methane increases (and the amount of unconverted methane decreased) with an increase of oxygen. The hydrogen and carbon monoxide content

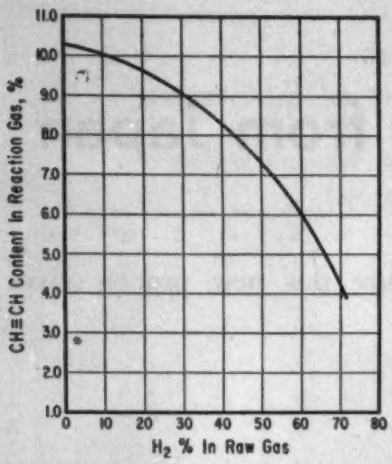

FIGURE 3—Effect on acetylene yield of changing hydrogen content of the raw gas.

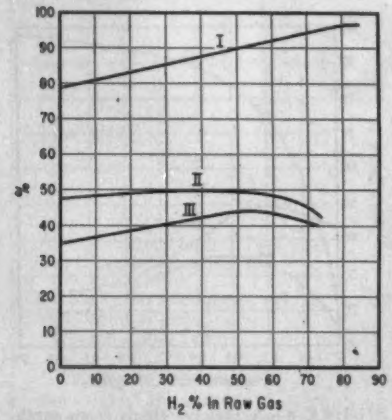

FIGURE 4—Yield of acetylene as it is affected by hydrogen content of the raw gas. The oxygen-methane ratio was held constant. I. Percentage conversion of methane; II. Acetylene yield from reacted methane; III. Acetylene yield from raw methane.

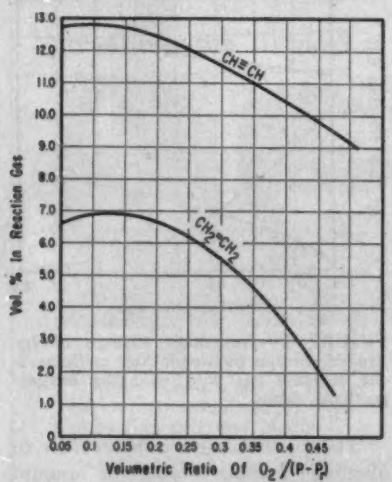

FIGURE 5—Changes in the acetylene and ethylene content of the reaction gas with varying oxygen to propane-propylene ratios.

of the reaction gases increased as the ratio of oxygen was increased. When the ratio was 0.6, a gas composed of 3 percent methane, 23 percent carbon monoxide, 58 percent hydrogen and 7 percent acetylene was obtained. This composition is similar to that obtained from the Sachsse process which uses the same ratio.

Effect of hydrogen on acetylene production. Next, the production of acetylene from methane in the presence of hydrogen was carried out. At a constant oxygen to methane ratio of 0.25, a mixture of methane, oxygen and hydrogen was passed over 5-10 grams of silica under similar conditions as in the case of pure methane. The changes in acetylene content of the reaction gases with various amounts of hydrogen in raw gases are shown in Figure 3.

The acetylene content in the reaction gases decreased with an increase in added hydrogen (see Figure 3), whereas the yield of acetylene from raw methane and reacted methane was a maximum when the amount of hydrogen added was about 65 percent. Methane conversion increased to 95 percent as the amount of hydrogen added was increased (Figure 4). Thus a yield of about 50 percent acetylene was obtained from a methane and hydrogen mixture.

Non-catalyzed Production of acetylene from Methane. As described above, production of acetylene from methane was satisfactory, but a reduced pressure of 6-60 mm Hg is considered too low for industrial production. Moreover, silica, which was used as catalyst, was not suitable because of its low melting point. For the above reasons, the reactions were carried out without a catalyst and at a higher pressure of 200-300 mm Hg.

In a 35 mm internal diameter porcelain tube a 7 mm internal diameter tube was inserted and 43 cm zone was electrically heated to 1200 C. A mixture of methane and oxygen was passed through these tubes at the rate of 1.2-2.0 m^3/hr under a reduced pressure of 200-300 mm Hg.

The smaller tube was used to preheat raw gas and the exit gas from this tube was then cracked in the annular space between the inner and outer tubes.

The changes of acetylene content in the reaction gases with the ratio of oxygen to methane differed from those when using silica catalyst and under lower pressure of 6-60 mm Hg.

Table 1 shows the acetylene content in the reaction gases with varying oxygen-methane ratios obtained by non-catalyzed reaction of methane with oxygen.

TABLE 1—Non-Catalyzed Acetylene Production From Methane-Oxygen

O_2/CH_4 Vol. Ratio	0.2	0.3	0.37	0.47	0.65
Acetylene Content (Percent)	5.0	5.7	7.7	8.4	7.0
Conversion of Methane (Percent)	47	70	74	75	78
Yield of Acetylene From Reacted Methane (Percent)	18	32	42	45	41

Comparing the results in Table 1 with the results from 6-60 mm Hg pressure, notice that the optimum ratio of oxygen to methane deviates from 0.2-0.3 to 0.4-0.5.

In this new acetylene process the mixture of hydrogen and carbon monoxide obtained as a by-product is converted to methane. A portion of converted methane is purged, mixed with pure methane, and then converted to acetylene by the above method.

Acetylene-Ethylene from Propane-Propylene. The production of acetylene-ethylene mixture from propane-propylene (50-70 percent olefins) was carried out under similar conditions as in the case of methane. At first silica was used as a catalyst, but the results were nearly the same as when no catalyst was used.

When propane-propylene was cracked to produce an acetylene-ethylene mixture, more than 25 percent hydrogen was necessary, to prevent tar and carbon from clogging the reaction tube.

Figure 5 shows the acetylene and ethylene content in the reaction gases at various ratios of oxygen to propane-propylene when the mixed gases contained 62-69 percent hydrogen.

The acetylene and ethylene content in the reaction gases reached a maximum of 12.8 and 6.8 percent respectively when the ratio was 0.05. The acetylene and ethylene yields from propane-propylene are shown in Figure 6. Also notice the percentage of conversion of propane-propylene is nearly 100 percent. The maximum yields of acetylene and ethylene were 59 and 31 percent respectively

and it is possible to obtain 59 liters of acetylene and 31 liters of ethylene from 100 liters of propane-propylene mixture.

The effect of adding hydrogen to the propane-propylene-oxygen mixture was investigated while the ratio of oxygen to propane-propylene was maintained at 0.18-0.20. The results are shown in Figures 7 and 8.

The acetylene content in the reaction gases was a maximum when the raw gases contained 25-35 percent hydrogen; whereas, the ethylene content was maximum when hydrogen content of raw gases was 35-40 percent. The yield of acetylene reached 57 percent when raw gases contained 65 percent hydrogen, but the yield of ethylene was at the maximum of 29 percent when hydrogen content of the raw gases was between 40-55 percent.

Acetylene-Ethylene from Butane-Butylene. A butane-butylene fraction containing about 55 percent olefins was used as the raw material. As in the case of propane-propylene, it was found that the presence of a certain amount of hydrogen was strictly necessary.

At the beginning of this research it was assumed that butane-butylene would produce propylene and methane when cracked, but the experimental results revealed that the B-B fraction was cracked at the middle of molecules, producing main products of acetylene and ethylene. 78 liters of acetylene and 80 liters of ethylene have been obtained from 100 liters of butane-butylene mixture in the presence of 31 percent of hydrogen. Typical results are shown in Table 2.

TABLE 2—Yields of Acetylene and Ethylene From Butane-Butylene

Ratio of Oxygen to B-B, Vol.	0.075	0.19	0.45
Vol. of Acetylene from 100 Vol. of B-B	78	78	84
Vol. of Ethylene from 100 Vol. of B-B	80	70	60
Total	158	148	144

The acetylene and ethylene contents in the reaction gases obtained from butane-butylene were as high as 14.4 and 14.8 percent respectively. On the other hand, carbon monoxide content was as small as 3-4 percent.

It was confirmed that B-B fractions were superior to propane-propylene fractions as the raw materials for the production of acetylene and ethylene.

Acetylene from Ethylene. Ethylene was reacted with oxygen in the presence of 25 percent hydrogen under similar conditions to that of butane-butylene.

The acetylene content of reaction gas was as high as 22.2 percent and 54 liters of acetylene were obtained from 100 liters of ethylene and 45 liters of the original ethylene were recovered.

Acetylene from Tsutsumi Vacuum Cracking[2] Tail Gas. The cracked gas obtained by vacuum[2] consist of about 30-35 percent ethylene, 15-20 percent propylene, 20-25 percent hydrogen and 25-30 percent C_1-C_2 paraffins. This gas was reacted with oxygen (20-30 percent for olefins) under similar conditions to C_3-C_4 hydrocarbons and about 30 liters of acetylene and 20 liters of ethylene were obtained from 100 liters of raw gas.

Industrial Applications. As described above, in this new process an optional amount of oxygen can be used for hydrocarbons, and when a smaller amount of oxygen is used, it may be difficult to use a burner type reactor. The development of a surface combustion type reactor to be used in the industrial application of this new process is now in progress.

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[1] Sachsse Acetylene, Petroleum Refiner, Vol. 33, No. 11, Nov. (1953), p. 120.

[2] "Now—Petrochemicals from Resid," Shigeru Tsutsumi, Petroleum Refiner, Vol. 36, No. 9, Sept. (1957), p. 287.

About the Author

Shigeru Tsutsumi is a professor at Osaka University, Osaka, Japan. In March, 1932, he graduated from Tokyo Imperial University, and in April, 1940, received his Ph.D. degree. In 1935 Tsutsumi was an engineer in the Fuel Research Institute, then in 1940, he became a professor at Osaka University and a member of the Institute of Scientific and Industrial Research. In 1949 he was placed in charge of applied chemistry on the faculty of engineering at Osaka University.

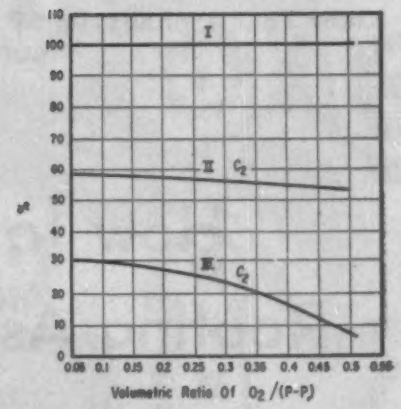

FIGURE 6—Acetylene yields vary with oxygen-to-propane-propylene ratios. Conversion of propane-propylene (I); Yields of acetylene (II) and ethylene (III).

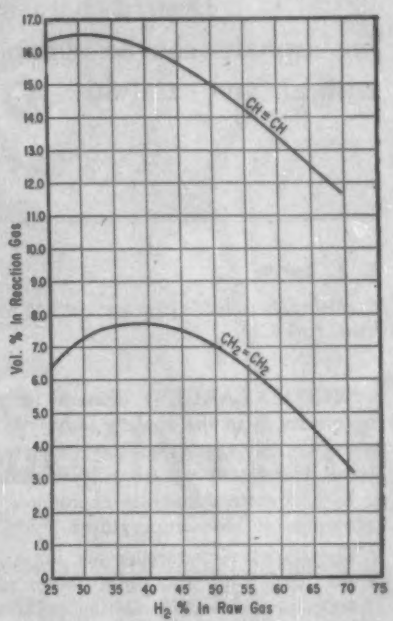

FIGURE 7—Adding hydrogen has this effect on acetylene and ethylene content.

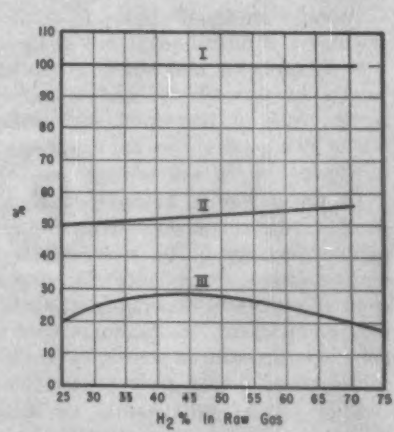

FIGURE 8—Hydrogen affects conversion of propane-propylene (I). Yields of acetylene (II) and ethylene (III).

How to Make Roofing Asphalts

Desired characteristics of roofing asphalts can be obtained by blowing with air and catalysts.

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New York City

SECOND LARGEST demand for asphalts, after paving grades, is in the roofing industry. Roofing grades fall into two main groups—the saturants and the coating types. The latter call for rugged materials to resist flow at high climate temperatures and for pliability and non-brittleness at low temperatures.

These special properties are imparted by air blowing liquid, semi-solid and solid fluxes of straight reduced asphalts to the desired melting point and other user specifications. Raw stocks suitable for blowing range from 150 to 1000 seconds, Furol viscosity at 210 F.

Asphalts are usually blown in vertical towers. Generally the tower is three-fourths full at the operating temperature. A spray circular nozzle at the bottom of the tower injects air through the molten asphalt. Older arrangements, such as horizontal shell stills, are still in use. These give good service for batch operations, but are not as efficient as vertical towers.

Incoming flux is heated or taken directly from the straight run vacuum or atmospheric towers without further preheating. In continuous operations the inlet temperature is about 515 F. Blowing temperatures range from 485 to 590 F. depending on stocks, desired end products, catalyst, etc. Air quantities used range from 5 to 20 cubic feet per minute per ton of flux, depending on tower construction, nozzle arrangement, temperatures, etc.

After a short initial period the reaction becomes exothermic and to regulate temperature, the tower is equipped with water coils for cooling purposes. Steam purging is provided for the vapor area of the tower above the asphalt level. Verticle towers may be arranged in series of two or more for greater throughput or longer contact time. The still and tower operates continuously, unless batch methods are used, with the blown asphalt of of the desired melting point leaving the tower at about 400-475 F. directly or through coolers to storage tanks.

The reaction is chemical and mainly one of dehydrogenation accompanied or followed by condensation of the molecules of unsaturated nature into higher molecular weight material. Penetration decreases as melting point rises. The reaction may be written:

$$C_nH_{2n-8} + O = C_nH_{2n-10} + H_2O$$

Sulfur, selenium and tellurim (all in the same perodic group with oxygen) will accomplish the same purpose.

Mechanical agitation is practiced where air economy is important. Blowing under pressure is of value in obtaining certain characteristics of the finished material. The tower bottoms can be recirculated to the pipe still or mixed with fresh incoming flux to the tower or still as desired. Asphalts blown batchwise in towers can be finished to medium melting point in about eight hours. However, continuous operation is less time consuming, with greater throughput. Exit gases are analyzed for oxygen content to control explosive mixtures.

Catalysts are being used to accelerate the reaction. Some appear to be consumed in the reaction often imparting special properties to the asphalts. The catalysts are mostly anhydrous heavy metal chlorides though recently phosphorous pentoxide is being used. Beneficial effects are also claimed for ferric chloride containing six molecules of water. Exit gases pass through a scrubber to remove and condense light distillates, with the washed gases being used as fuel in the still.

General Properties of Roofing Asphalts

TESTS	Saturants		Coating	Mopping	
	Roll	Shingle		(1)	(2)
Penetration, 32 F.	31	12	10	9	19
Penetration, 77 F.	140	30	17	18	31
Penetration, 115 F.		80	30	47	59
Melting Point (R&B)	108	155	217	176	194
Penetration Index (Shell)	—0.7	1.4	4.5	2.1	4.5
Ductility at 77 F. (Centimeters)	100+	12.0	3.0	7.5	4.9

The relation between melting point, (R&B) and penetration is most important. These properties can be varied considerably by using fluxes of certain origins and make-up. Other tests required on the finished products are:—spot test, gravity, flash fire tests, low temperature ductility, various solubility tests, pliability, brittleness and tests required by the user of the blown material.

The solubility in 86-degree Pennsylvania light naphtha is useful to indicate the degree of blowing. The reaction can be followed and plotted by this determination. The melting point during blowing increases slowly with drop in penetration with an abrupt rise toward the end of the operation during which the penetration shows very little decrease.

Part 8 will appear in an early issue

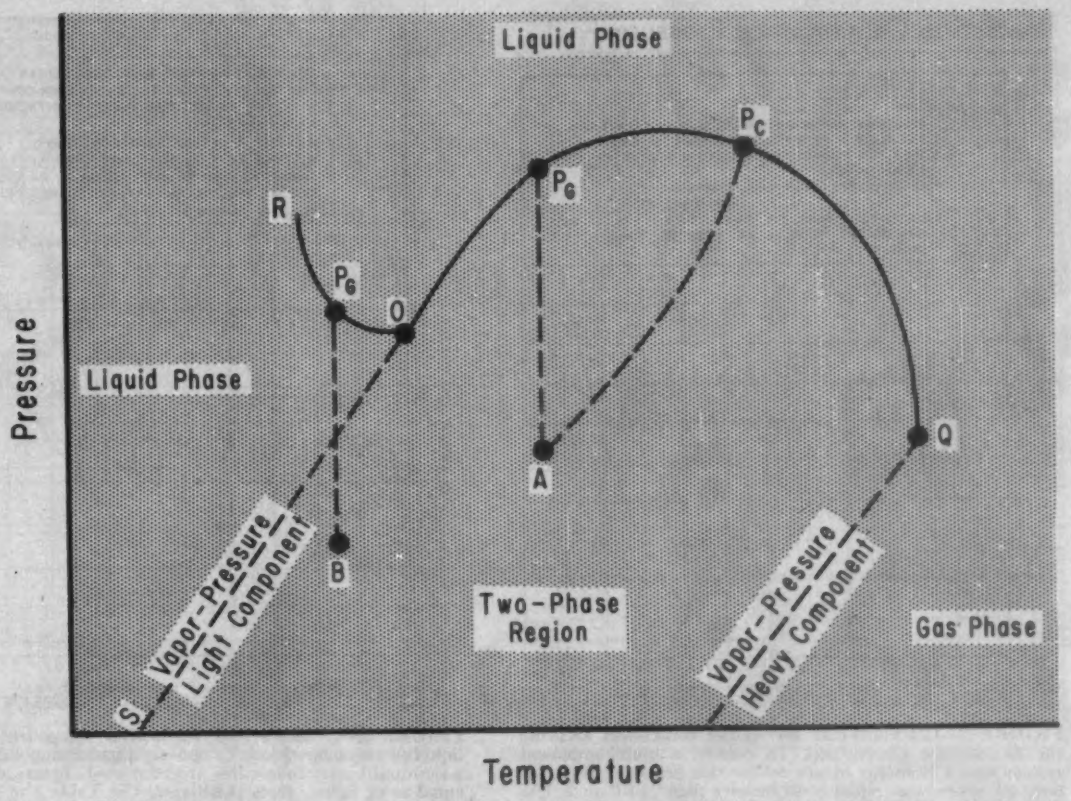

FIGURE 1—Temperature-pressure diagram showing liquid and vapor regions for a typical hydrocarbon binary. The curve OQ is the locus of critical points for all compositions.

Predicting Convergence Pressure

Use this method for predicting equilibrium constants for multicomponent mixtures for a wide range of temperature and pressure. This method is good for various mixtures, including paraffins, olefins, naphthenes, aromatics and non-hydrocarbons which normally occur in hydrocarbon mixtures.

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THE USE OF convergence pressures to establish equilibrium ratios has been described in earlier publications.[12,21,23] The main advantage of using convergence pressure as a correlating parameter is that it takes into account the effect of composition on equilibrium ratios. In most cases, the effect of composition is more important at high pressures than at low pressures. But with the graphical procedures given in this paper, the importance of composition, for any condition, can be determined easily and quickly before starting computations. The method is easily used and gives accurate results for a wide range of temperatures and components.

Convergence pressure can be conveniently described with the aid of Figure 1, a temperature-pressure diagram showing liquid and vapor regions for a typical hydrocarbon binary. The curved line OQ is the locus of critical points for all compositions. The convergence pressure,

Predicting Convergence Pressure . . .

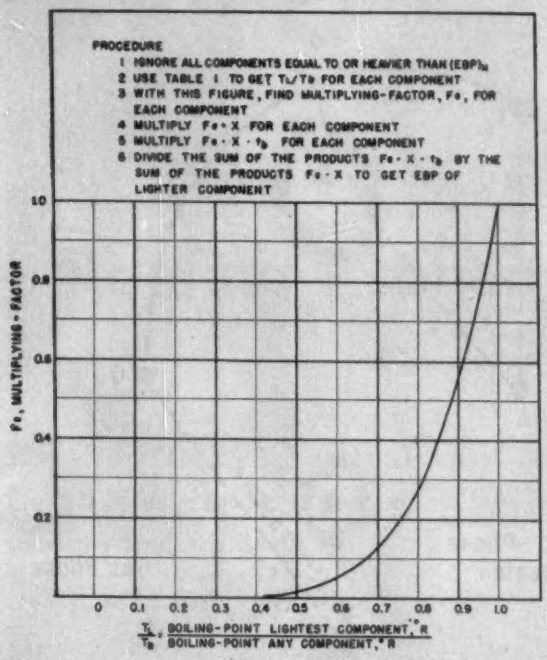
PROCEDURE
1 IGNORE ALL COMPONENTS EQUAL TO OR HEAVIER THAN (EBP)H
2 USE TABLE 1 TO GET TL/Tb FOR EACH COMPONENT
3 WITH THIS FIGURE, FIND MULTIPLYING-FACTOR, Fe, FOR EACH COMPONENT
4 MULTIPLY Fe • X FOR EACH COMPONENT
5 MULTIPLY Fe • X • tb FOR EACH COMPONENT
6 DIVIDE THE SUM OF THE PRODUCTS Fe • X • tb BY THE SUM OF THE PRODUCTS Fe • X TO GET EBP OF LIGHTER COMPONENT
Fe, MULTIPLYING-FACTOR
TL/Tb = BOILING-POINT LIGHTEST COMPONENT, °R / BOILING-POINT ANY COMPONENT, °R

FIGURE 2—Calculate EBP for lighter component knowing the liquid-phase composition. To convert a multicomponent system into a fictitious binary follow this procedure:—1. Ignore all components equal to or heavier than $(EBP)_H$; 2. Use Table 1 to get T_L/T_b for each component; 3. With this figure, find multiplying factor, F_e, for each component; 4. Multiply Fe • X for each component; 5. Multiply Fe • X • t_b for each component; 6. Divide the sum of the products Fe • X to get EBP of lighter component.

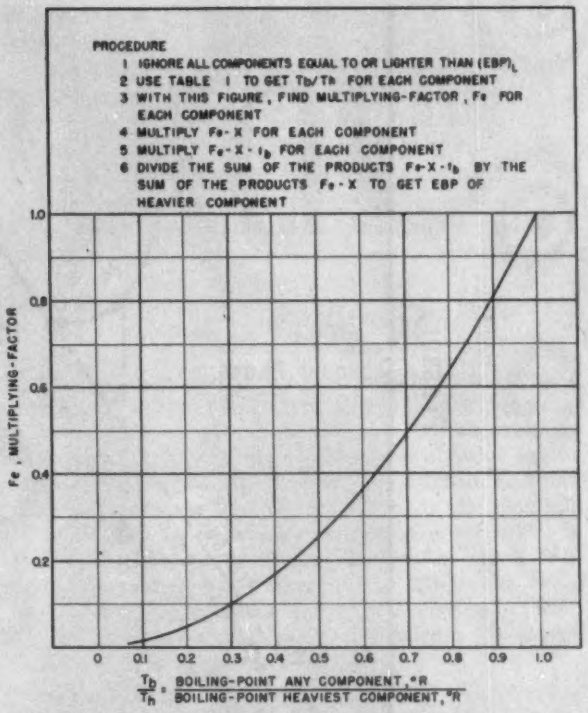
PROCEDURE
1 IGNORE ALL COMPONENTS EQUAL TO OR LIGHTER THAN (EBP)L
2 USE TABLE 1 TO GET Tb/Th FOR EACH COMPONENT
3 WITH THIS FIGURE, FIND MULTIPLYING-FACTOR, Fe FOR EACH COMPONENT
4 MULTIPLY Fe • X FOR EACH COMPONENT
5 MULTIPLY Fe • X • tb FOR EACH COMPONENT
6 DIVIDE THE SUM OF THE PRODUCTS Fe • X • tb BY THE SUM OF THE PRODUCTS Fe • X TO GET EBP OF HEAVIER COMPONENT
Fe, MULTIPLYING-FACTOR
Tb/Th = BOILING-POINT ANY COMPONENT, °R / BOILING-POINT HEAVIEST COMPONENT, °R

FIGURE 3—Calculate EBP for heavier component knowing the liquid-phase composition. To convert a multicomponent system into a fictitious binary follow this procedure:—1. Ignore all components equal to or lighter than $(EBP)_L$; 2. Use Table 1 to get T_b/T_h for each component; 3. With this figure, find multiplying factor, Fe for each component; 4. Multiply Fe • X for each component; 5. Multiply Fe • X • t_b for each component; 6. Divide the sum of the products Fe • X • t_b by the sum of the products Fe • X to get EBP of heavier component.

P_g, of a mixture represented by point *A* is the projection of the operating pressure to the critical locus at constant temperature. And the critical pressure, P_c, of mixture *A* is the projection of the operating pressure to the critical locus at constant composition. The curve *OR* represents a quasi-convergence locus that will be discussed later.

For a binary mixture, the identity of the components establishes the critical locus. And the temperature fixes the convergence pressure. For ternary and multicomponent mixtures, no such simple relationship exists. But a multicomponent mixture can be considered to be a fictitious binary.[12,21] And an effective binary can be constructed from the boiling points of the components. The resultant binary establishes a critical-locus curve from which convergence pressures can be obtained for given temperatures.

The procedure for converting a multicomponent mixture to a ficti-

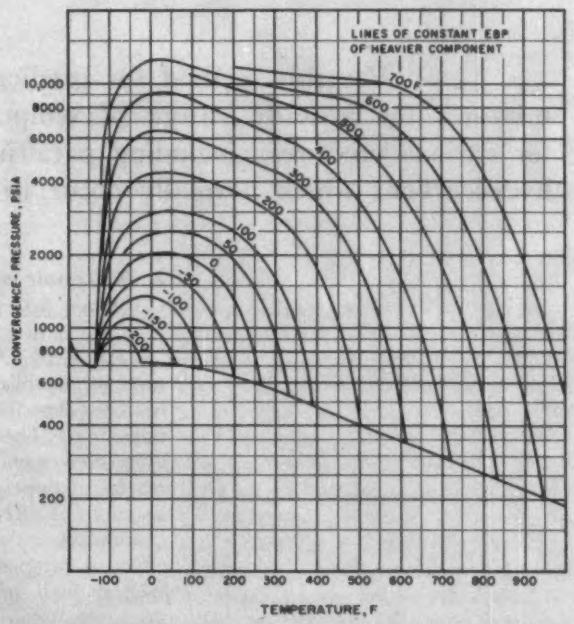

FIGURE 4—Convergence pressures for light component of mixtures, EBP = — 280 F with parameters of EBP_H. Logarithmic interpolation may be used.

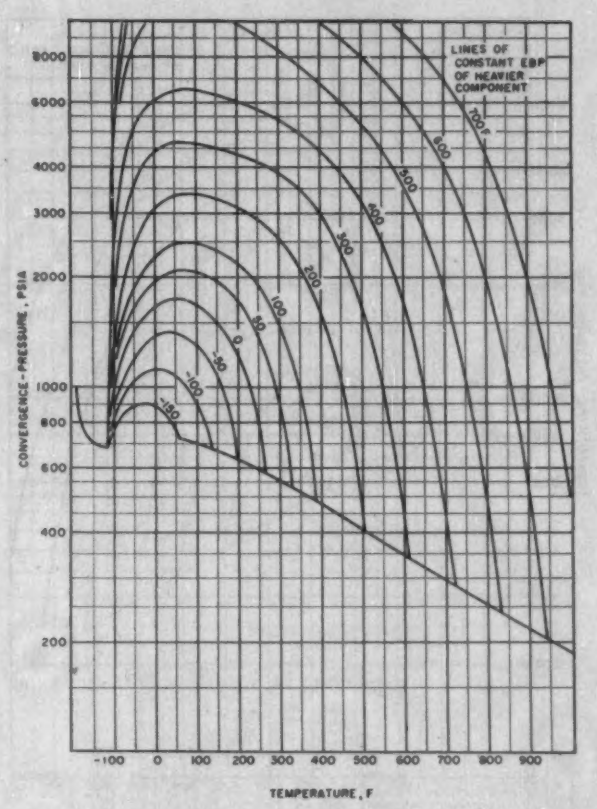

FIGURE 5—Convergence pressures for lighter component of mixtures, EBP = — 259 F with parameters of EBP_H.

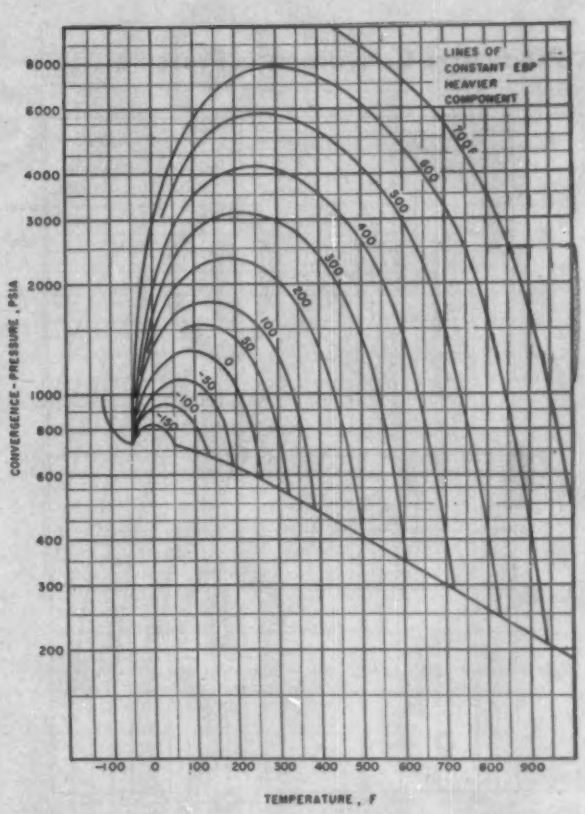

FIGURE 6—Convergence pressures for lighter component of mixtures, EBP = — 220 F with parameters of EBP_H.

tious binary involves the computation of effective boiling points (EBP) of the fictitious light and heavy components. Figures 2 and 3 show how the computations are made, knowing the liquid-phase composition. For these computations, each component has an effective boiling point given in Table 1. Paraffin and olefin hydrocarbons have an EBP that is the same as their normal boiling points. Aromatics, naphthenes, acetylenes, and non-hydrocarbons have an EBP that is the same as the normal boiling point of a hypothetical paraffin having the same critical temperature as the non paraffin. In determining EBP (effective boiling point) values, the most volatile component has the greatest effect on EBP_L and the effect of the heaviest component predominates in determining EBP_H.

Having determined values of EBP_L and EBP_H for the fictitious binary, its convergence pressure for a given temperature can be obtained by referring to an appropriate critical-locus curve. Figures 4 through 14 present a series of critical-locus curves. Each figure gives convergence pressures of mixtures with a given EBP_L and with a parameter of EBP_H. For intermediate values of EBP_L, logarithmic interpolation may be used. The construction of intermediate figures by crossplotting may save time and improve precision.

Example 1: As an example of the use of the convergence-pressure figures, first determine the convergence pressure of a mixture of methane and pentane at 106.4F. From Table 1, the effective boiling point of methane is —259F and of pentane 97F. From Figure 5 a convergence pressure of 2420 psia is found. Sage, Reamer, Olds, and Lacey[20] measured a value of 2445 psia. For paraffin and paraffin-olefin binary mixtures, Figures 4 through 14 predict measured values with an arithmetic average deviation of 2.7 percent. Table 2 lists deviation for 53 tests, using 16 mixtures.

Component	X	T_b	T_L/T_b	Fe_L	FeX	$FeXT_b$	EBP_L
COMPUTATION OF EBP_L							
methane	0.069	201	1.000	1.000	0.069	13.9	
ethylene	0.279	305	0.659	0.092	0.0257	7.84	
					0.0947	21.74	229 R,-231 F
COMPUTATION OF EBP_H							
ethylene	0.279	305	0.646	0.42	0.117	25.7	
isobutane	0.652	471	1.000	1.00	0.652	307.0	
					0.769	332.7	434 R,-26 F

Example 2: Compute the convergence pressure for a ternary mixture at 100F and 500 psia. The liquid-phase composition, in mole fraction, is 0.069 methane, 0.279 ethylene, and 0.652 isobutane.

Interpolation between Figures 5 and 6 gives a convergence pressure of 1280 psia. In this particular mixture, convergence pressure affects the equilibrium ratio of isobutane more than it does the equilibrium ratio of methane or ethylene. Using the value of

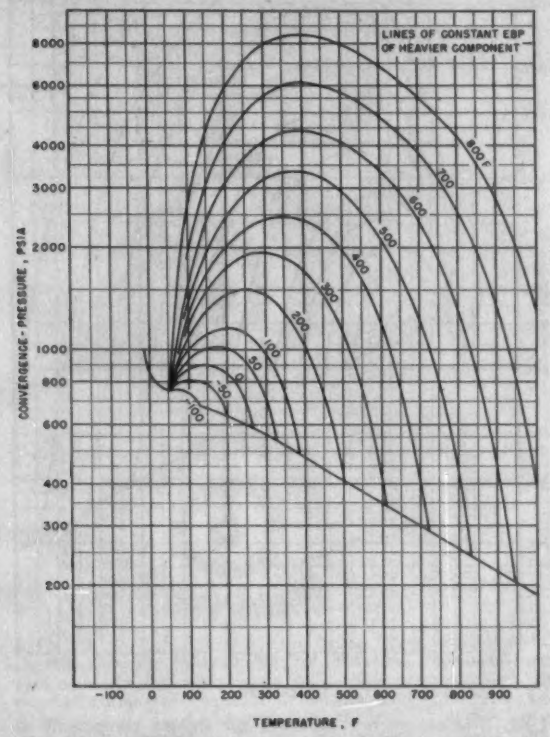

FIGURE 7—Convergence pressures for lighter component of mixtures, EBP = — 155 F with parameters of EBP_H.

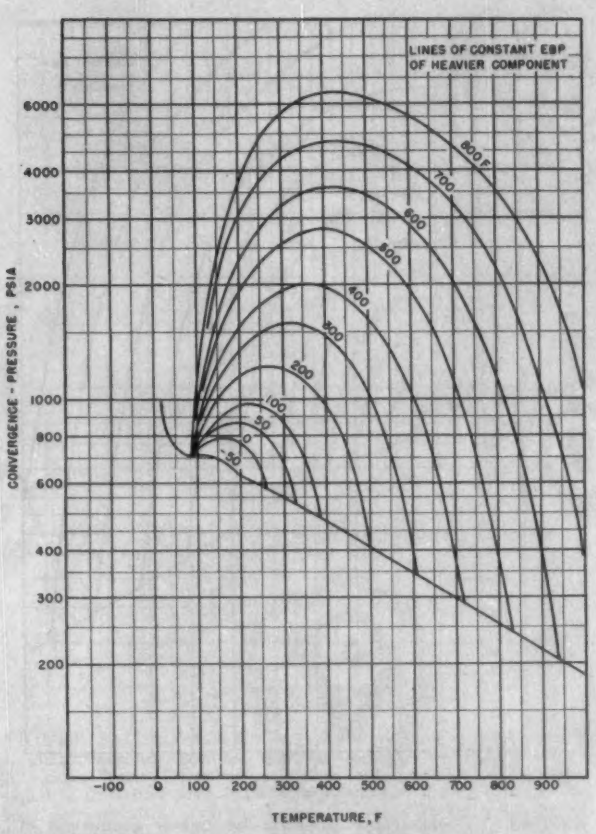

FIGURE 8—Convergence pressures for lighter component of mixtures, EBP = — 128 F with parameters of EBP_H.

1280 psia for P_g, a value of 0.285 for the isobutane equilibrium ratio is computed[23] and compares with a measured[2] value of 0.281.

Comparisons. Table 3 shows a comparison of convergence pressures predicted by the above method, with experimentally-determined values. Predicted values agree with measured values with an arithmetic deviation of 3.7 percent. This comparison is limited to multicomponent mixtures of paraffins and narrow boiling-range oils having a high Watson characterization factor. This is necessary to eliminate consideration of activity coefficient effects. Where the oil portion is identified by ASTM distillation, it is recommended that the 60-percent point temperature be used to represent the temperature of the petroleum fraction.

It has been suggested[12] that the EBP_L value for multicomponent mixtures is identical with the normal boiling point of the lightest component. Using this approach for Example 2, a convergence pressure of 1500 psia is obtained, and K for isobutane is 0.269. The discrepancy is not particularly serious for this case, illustrating the predominant effect that the lightest component has in establishing EBP_L, and secondly that great accuracy in establishing the convergence pressure is often not necessary. Whenever the concentration of the lightest component is appreciable, there is seldom need to compute EBP_L, since it is essentially identical with the EBP value of the lightest component. However, when the lightest component is present in minor amounts, then the complete computation is warranted. The following two examples will illustrate these points.

Example 3: Assume a liquid-phase composition at 100F of 0.039 mole fraction methane, 0.372 ethylene, and 0.589 isobutane; computation gives an EBP_L of —214F, a convergence pressure of 1125, and K_{iC_4} of 0.296. By assuming an EBP_L equal to the EBP value for methane, a value of K_{iC_4} equal to 0.25 is obtained.

Trace amounts of methane in the same system (Example 3) lead to appreciable discrepancies. For a liquid-phase mixture of 0.001 mole fraction methane, 0.691 ethylene, and 0.308 isobutane, values for $P_g = 800$ psia and $K_{iC_4} = 0.350$ are obtained. But if EBP_L is assumed equal to EBP for methane, then $P_g = 1200$ psia and $K_{iC_4} = 0.285$, a 50 percent discrepancy in convergence pressure and an 18 percent error in equilibrium ratio.

Figure 15 illustrates the very large effect of traces of hydrogen on convergence pressure. In the use of equilibrium ratios for design purposes, trace amounts of light gases must be included in the computations. Other gases, as well as hydrogen, have the same effect on K values.

When operating pressures are near the computed convergence pressure, say within 60 percent, the convergence pressure must be computed with some accuracy. For pressures lower than 60 percent of the conver-

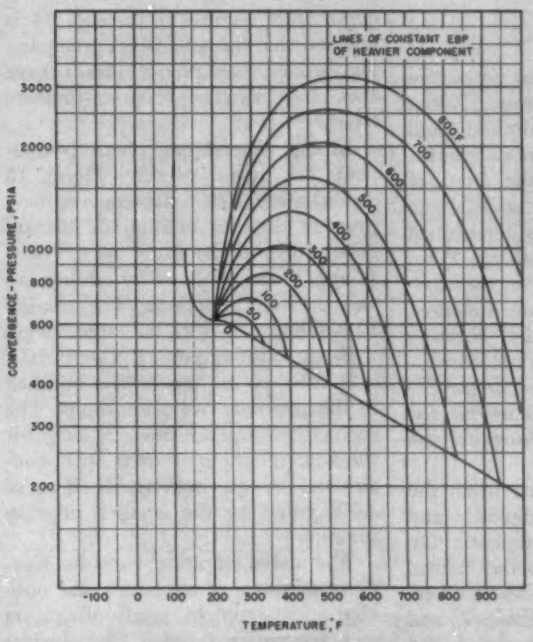

FIGURE 9—Convergence pressures for lighter component of mixtures, EBP = — 44 F with parameters of EBP_H.

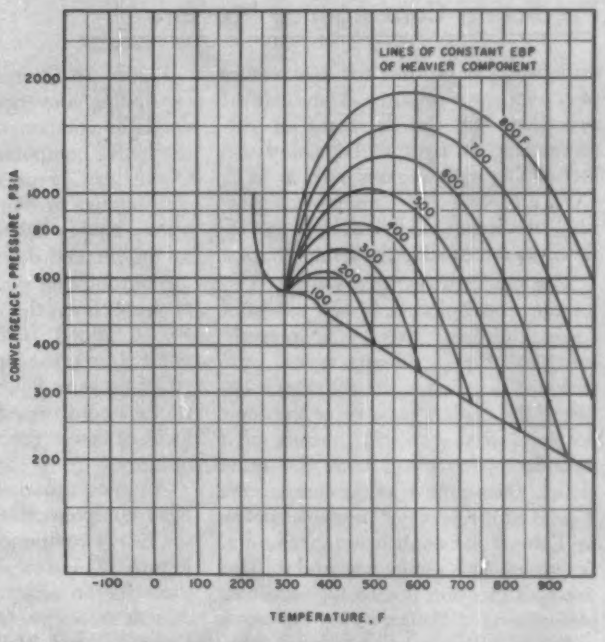

FIGURE 10—Convergence pressures for lighter component of mixtures, EBP = 31 F with parameters of EBP_H.

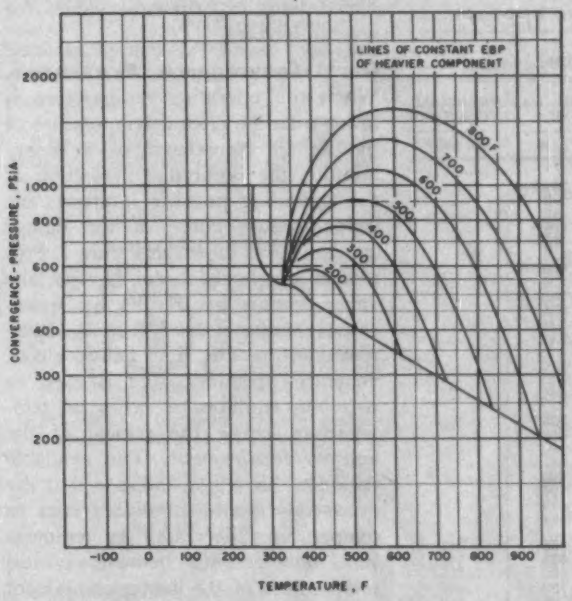

FIGURE 11—Convergence pressures for lighter component of mixtures, EBP = 50 F with parameters of EBP_H.

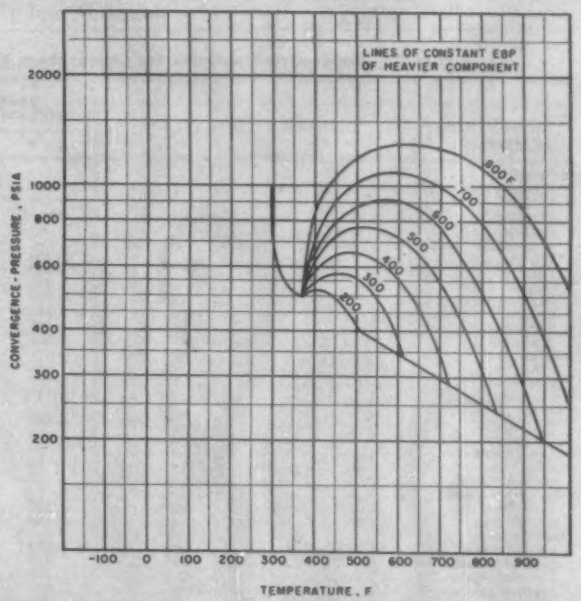

FIGURE 12—Convergence pressures for lighter component of mixtures, EBP = 80 F with parameters of EBP_H.

gence pressure, an estimate of the convergence pressure is usually adequate. A helpful rule for estimating EBP values of a multicomponent mixture is to estimate the EBP_L as the molal average of the EBP values for the components making up the lightest seven percent of the mixture. The estimate of EBP_H is the molal average of the heaviest 40 percent in the mixture. The 7-40 rule, with a little experience, makes it possible to select EBP values by inspection. This rule applies to the general case where equilibrium ratios are not a sensitive function of convergence pressure. Computation of the EBP values is required only when operating pressures are high relative to convergence pressures.

When nonaliphatic components are present in appreciable quantities, it is necessary to modify the procedure in order to obtain accurate values of convergence pressure. It is especially

important to do this for low values of convergence pressure. The modified procedure handles mixtures of different kinds of hydrocarbons, and also includes inorganic gases such as H_2S, CO_2, and CO. For convergence-pressure prediction, acetylene and its derivatives are classified as nonaliphatics.

The modification in this method to handle nonaliphatics is the use of a correction term called the pressure function. For a binary system, the pressure function is the difference between the critical pressure of the component and the critical pressure of a paraffin hydrocarbon with the same critical temperature as the component. Values of the pressure function appear in Table 1 for naphthenes, aromatics, acetylene, and nonhydrocarbons. The pressure function is zero for paraffins, olefins, and diolefins.

For a multicomponent system containing nonaliphatics, the pressure function is computed by the relation

$$P_f = \frac{\Sigma Fc_i X_i P_{fi}}{\Sigma Fc_i X_i}$$

Figure 16 illustrates the procedure for finding convergence pressure when the light component is aliphatic and the heavy component is nonaliphatic. Curve *ABC* represents the locus of convergence pressures for an aliphatic binary having EBP values determined by the method described above. From the terminating point *C*, on the base-pressure line, the pressure function, P_f, is added isothermally, locating point *D* on the appropriate convergence-pressure figure. The curve AED is then constructed to represent the locus of convergence pressures for the mixture.

Another situation occurs when the light component is nonaliphatic and the heavy component is aliphatic. On Figure 17, curve *ABC* is the critical locus for an aliphatic mixture determined as above from Table 1 and Figures 2 and 3. From point *A*, the pressure function is added isothermally, giving point *D*. The convergence-pressure locus passes through points *D* and *C*. The appropriate curve from Figures 4 through 14 is selected that has an EBP_H curve passing through these points. This is curve *DEC*, the desired convergence-pressure locus.

In the general case, both components are nonaliphatic. Figure 18 shows curve *ABC*, the convergence-pressure locus for an aliphatic mixture determined in the usual way. Points *D* and *F* are obtained by adding the two pressure functions. The smaller P_f is subtracted from the larger to get $\triangle P_f$, establishing point *E*. Curve *AGE* is located by the procedures outlined in the previous two paragraphs. The correct convergence-pressure locus for the nonaliphatic mixture is *DEF*, constructed by an isothermal offset of AGE equal to the smaller pressure function.

The above empirical rules for handling mixtures of aliphatics and nonaliphatics result in predicted values of convergence pressure that deviate from experimental values with an arithmetic average of 6.6 percent. Table 4 gives a comparison of predicted with experimental values for several binaries.

Quasi-Convergence Pressures. When the operating temperature is lower than the critical temperature of the lighter component of a binary mixture, the isothermal projection of this operating pressure intersects the vapor-pressure curve of the lighter component as shown in Figure 1. Projection of the isotherm beyond the vapor-pressure line results in a quasi-convergence-pressure[12] limit represented by line OR. This fictitious convergence pressure curve is used to correlate equilibrium ratios at temperatures below the critical of the lightest component. The available data for this region indicate that the quasi-convergence pressure rises as temperatures decrease. At temperatures more than 40F. below the critical temperature of the lighter component of a binary, or the equivalent lighter component of a multicomponent mixture, the quasi-convergence pressure is approximated as 5000 psia.

The exact locus of the quasi-convergence-pressure curve, or family of curves, has not been established. Figures 4 through 14 show a single curve for the quasi-convergence pressures. The location of these curves is approximate at best. But equilibrium ratios are fortunately somewhat insensitive to convergence pressure over most of

TABLE 1—Effective Properties for Convergence Pressures

COMPONENT	EFFECTIVE BOILING POINT		PRESSURE FUNCTION
	t_b, F	T_b, R	P_f, psia
n-Paraffins			
Methane	—259	201	....
Ethane	—128	332	....
Propane	—44	416	....
Butane	31	491	....
Pentane	97	557	....
Hexane	156	616	....
Heptane	209	669	....
Octane	258	718	....
Nonane	303	763	....
Decane	345	805	....
Undecane	384	844	....
Dodecane	421	881	....
i-Paraffins			
i-Butane	11	471	....
i-Pentane	82	542	....
i-Hexane	141	601	....
Olefins			
Ethylene	—155	305	....
Propylene	—54	406	....
Isobutylene	20	480	....
Butylene-1	21	481	....
cis-Butylene-2	39	499	....
trans-Butylene-2	34	494	....
Pentylene-1	86	546	....
Butadiene 1,3	24	484	....
Naphthenes			
Cyclopentane	176	636	225
Methylcyclopentane	216	676	142
Cyclohexane	232	692	205
Methylcyclohexane	269	729	140
Dimethylcyclohexane	306	766	140
Ethylcyclohexane	324	784	140
Propylcyclohexane	365	825	140
Aromatics			
Benzene	246	706	335
Toluene	301	761	272
o-Xylene	362	822	231
m, p-Xylene	352	812	199
Styrene	364	824	200
Ethylbenzene	347	807	238
Propylbenzene	389	849	164
Isopropylbenzene	376	836	164
Butyl Benzene	432	892	158
Acetylenes			
Acetylene	—120	340	205
Nonhydrocarbons			
Air	—300	160	....
Carbon Dioxide	—130	330	363
Carbon Monoxide	—288	172	....
Hydrogen	—398	62	....
Hydrogen Sulfide	—40	420	686
Nitrogen	—330	130	....
Water	397	857	2726

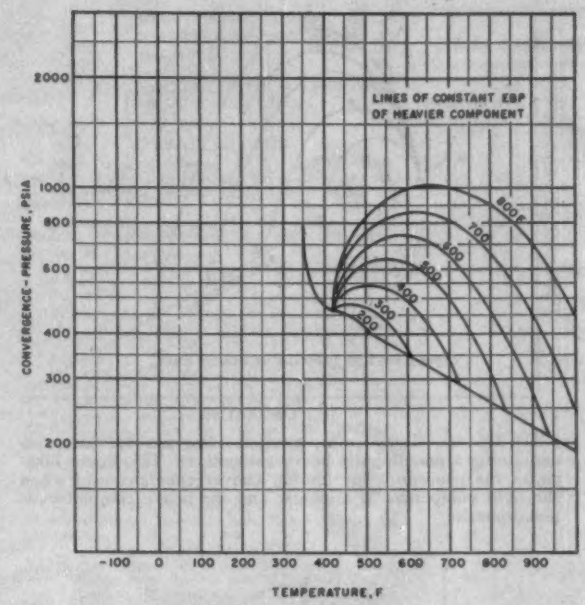

FIGURE 13—Convergence pressures for lighter component of mixtures, EBP = 120 F with parameters of EBP_H.

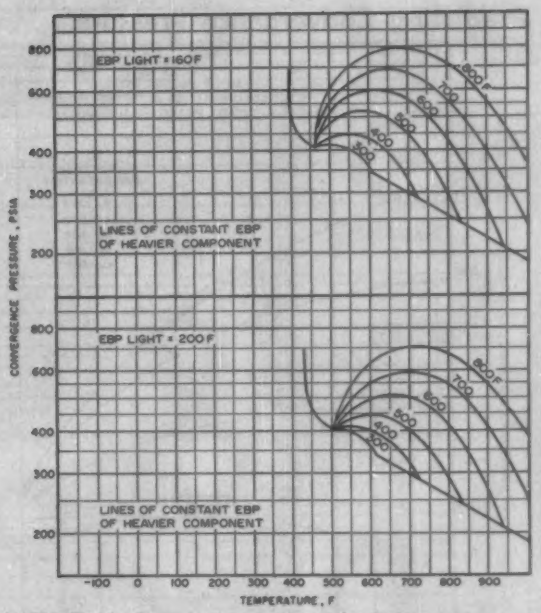

FIGURE 14—Convergence pressures for lighter component of mixtures, EBP = 160 F and 200 F with parameters of EBP_H.

this lower temperature range, especially when the operating temperature becomes appreciably lower than this critical temperature of the lighter component.

(Copies of the charts, presented in more detail, are available from the authors on request.)

NOMENCLATURE

EBP — Effective boiling point, degrees F or R

EBP_H — EBP for less volatile component, real for binaries, hypothetical for multicomponent mixtures, degrees F or R

EBP_L — EBP for more volatile component, real for binaries, hypothetical for multicomponent mixtures, degrees F or R

Fc — Multiplying factor for computing EBP values

i — Identity of a component

K — Equilibrium ratio

P_f — Pressure function, psi

P_c — Convergence pressure, psia

QP_c — Quasi-convergence pressure, psia

T_b — EBP value from Table 1 for a component, degrees R

t_b — EBP value from Table 1 for a component, degrees F

T_h — EBP value from Table 1 for least volatile component in a multicomponent mixture, degrees R

T_L — EBP value from Table 1 for

TABLE 2—Prediction of Convergence Pressures Binary Aliphatic Hydrocarbon Mixtures

REFERENCE	Mixture	Temp. F	Measured Pg	Predicted Pg	Percent Deviation
5	C_1—C_3	—108	713	720	1.0
		—92	784	800	2.1
		—31	976	970	—0.6
		50	897	930	3.7
		84	741	770	3.8
1	C_1—C_3	32	1450	1420	—2.1
		—25	1370	1310	—3.6
		—76	1060	1060	0
31	C_1—C_3	195	716	720	0.5
		182	847	860	1.5
		165	990	990	0
		123	1256	1240	—1.3
		60	1451	1420	—2.1
26	C_1—iC_4	100	1679	1720	2.4
		160	1457	1510	3.4
38	C_1—C_4	266	1093	1000	—8.3
		164	1799	1700	—5.5
		59	1924	1950	1.4
39	C_1—C_5	332	1115	1150	3.1
		278	1635	1695	3.7
		225	2043	2070	1.3
		106	2445	2450	0.2
30	C_1—C_{10}	100	5310	5400	1.7
		220	4935	4980	0.9
		340	4163	4200	0.8
		460	2911	2880	—1.1
22	C_2—$C_2^=$	100	720	710	—1.4
		160	710	690	—2.8
		180	690	660	—4.3
15	C_2—C_4	237	781	790	1.2
		148	827	830	0.4
		108	759	760	0
14	C_2—C_7	374	1106	1110	0.4
		277	1263	1250	—1.0
		120	850	880	3.5
24	C_2—C_4	280	609	605	—0.7
		243	638	635	—0.5
40	C_2—iC_5	231	649	650	0
		250	663	665	0.3
		288	651	675	3.7
		358	528	545	3.2
16	C_4—C_7	492	452	460	1.8
		366	596	625	5.2
		325	576	585	1.6
31	C_4—C_{10}	340	595	650	9.2
		460	700	760	8.6
7	C_5—C_7	410	495	495	0
17	$C_5^=$—C_7	482	452	430	—4.9
		504	472	460	—2.5
		464	758	710	—6.3
		253	1516	1530	0.9
		157	1319	1345	2.0
		83	932	980	5.2

Predicting Convergence Pressure . . .

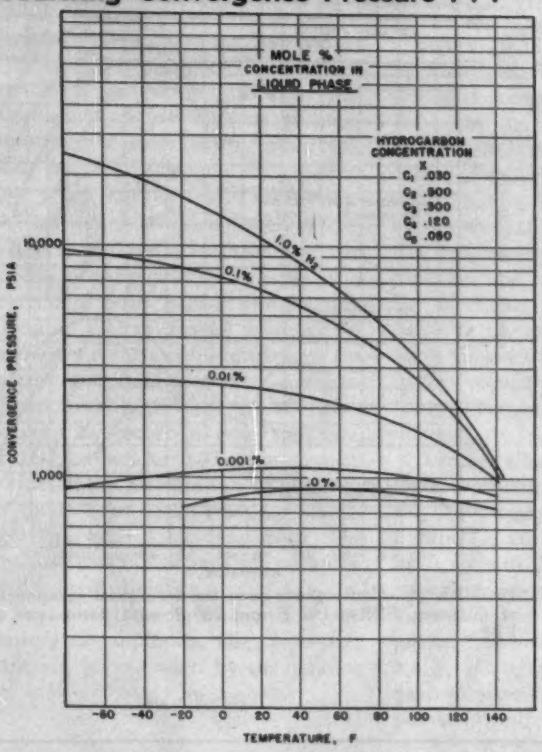

FIGURE 15—Notice the very large effect that traces of hydrogen can have on convergence pressure. Other gases as well as hydrogen have the same effect on K values.

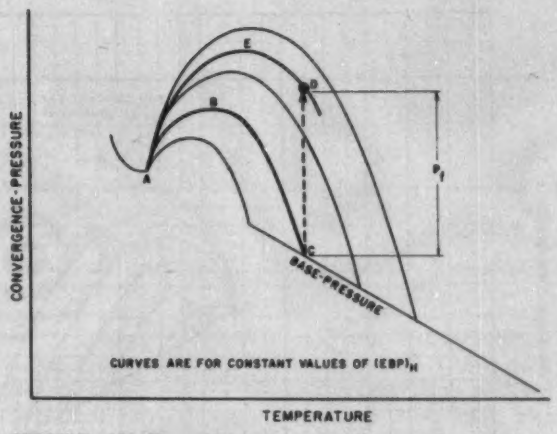

FIGURE 16—Temperature-pressure diagram for mixtures containing a nonaliphatic heavy component. This figure illustrates the procedure for finding convergence pressure when the light component is aliphatic and the heavy component is nonaliphatic.

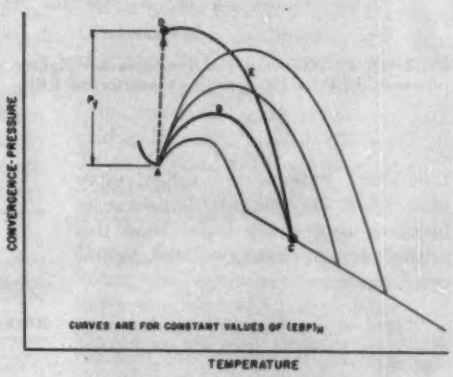

FIGURE 17—Temperature-pressure diagram for mixtures containing a nonaliphatic light component. Curve ABC is the critical locus for an aliphatic mixture determined from Table 1 and Figures 2 and 3.

TABLE 3—Prediction of Convergence Pressures Multicomponent Aliphatic Mixtures

Ref.	Mixture	Temp. F	Measured Pg	EBPL	EBPH	Predicted Pg	Percent Deviation
9	C_1–C_3–C_5	160	2200	—259	80	2140	—2.7
		160	1998	—259	60	2050	2.6
		160	1774	—259	31	1740	—1.9
		160	1425	—259	0	1470	—3.2
6	C_1–C_3–C_5	100	2380	—259	80	2320	—2.5
		100	2230	—259	60	2200	—1.3
		100	1998	—259	31	1910	—4.4
		100	1720	—259	0	1700	—1.2
4	C_1–C_3–C_5	100	2360	—258	78	2280	—3.4
		100	2150	—257	54	2090	—2.8
		100	1840	—254	22	1805	—1.9
		100	1400	—236	—36	1300	—7.1
32	C_1–C_4–C_{10}	40	2700	—259	156	2820	4.5
		40	3550	—259	230	3700	4.2
		40	4400	—259	280	4350	—1.1
		40	4900	—259	318	4900	0
29	C_1–C_4–C_{10}	160	2770	—259	156	2800	1.1
		160	3750	—259	230	3620	—3.5
		160	4420	—259	280	4260	—4.1
		160	4900	—259	318	4800	—2.0
32	C_1–C_4–C_{10}	280	2250	—259	156	2200	—2.2
		280	3200	—259	230	3100	—3.1
		280	3800	—259	280	3700	—2.7
		280	4300	—259	318	4300	0
36	C_1–C_3–C_3–C_4–C_5–C_6–oil BP = 275 F	40	3600	—258	224	3600	0
		120	3800	—258	234	3670	—3.4
		200	4000	—258	241	3780	—5.5
35	C_1–C_3–C_3–C_4–C_5–C_6–oil BP = 525 F	200	10000	—259	482	9100	—9.0
37	C_1–Kensol Oil	300	9500	—259	575	10000	5.2
		400	7800	—259	575	8400	7.7
		500	6100	—259	575	6600	8.2
		600	4500	—259	575	4900	8.9
		700	2900	—259	575	3000	3.3
43	Naphtha-Furnace Oil	475	630	115	600	676	7.1
		545	750	115	600	750	0
		615	800	115	600	760	—5.0
		660	770	115	600	718	—5.8
43	Pentane-Furnace Oil	492	730	97	600	795	8.9
		572	850	97	600	850	0
		615	855	97	600	834	—2.5
		690	760	97	600	728	—4.2
		760	585	97	600	570	—2.6
13	C_1–C_3–C_3–C_5–C_6	100	2000	—253	70	2125	6.2
	C_1–C_3–C_3–C_6–C_5	100	2200	—258	62	2160	—1.9

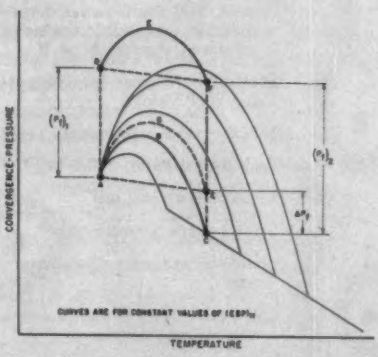

FIGURE 18—Temperature-pressure diagram for mixtures containing both light and heavy nonaliphatic components. Curve ABC is the convergence pressure locus for an aliphatic mixture determined in the usual way. The correct convergence pressure locus for the nonaliphatic mixture is DEF.

most volatile component in a multicomponent mixture, degrees R

X — Mole fraction of a component in the liquid phase

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TABLE 4—Prediction of Convergence Pressure Binary Systems Containing Nonaliphatics

Reference	Mixture	Temp. F	Measured Pg	Predicted Pg	Percent Deviation
10	C_1–Benzene	150	4830	4400	—8.3
	C_1–Toluene	150	5420	5100	—5.9
20	C_2–Benzene	513	916	950	3.7
		439	1232	1350	9.6
		271	1381	1540	11.5
		127	869	970	11.6
18	C_3–Cyclohexane	282	1328	1410	6.6
		371	1272	1340	5.1
		421	1134	1190	4.9
		508	757	795	5.0
42	C_3–Toluene	548	572	590	3.1
		527	549	577	5.1
		495	513	530	3.3
33	C_1–H_2S	190	1473	1400	—5.0
		130	1812	1680	—7.3
		59	1954	1790	—8.4
19	C_2–H_2S	98	776	770	—0.8
		123	916	920	0.4
		155	1072	1090	1.7
		189	1217	1210	—0.6
33	C_3–H_2S	349	1087	880	—19.1
		289	1233	1140	—7.6
		258	1272	1250	—1.7
		235	1293	1290	—0.2
34	C_{10}–H_2S	220	1349	1330	—1.4
		280	1096	1526	—10.0
8	C_1–CO_2	56	1215	1140	—6.2
		2	1225	1160	—5.3
		—60	985	1010	2.5
33	C_2–CO_2	100	1000	1050	5.0
		130	992	1000	0.8
		160	976	940	—3.7
28	C_3–CO_2	101	1002	1030	2.8
		147	986	930	—5.7
		199	780	720	—7.7
28	C_4–CO_2	120	1122	1090	—2.9
		169	1181	1100	—6.9
		254	940	880	—6.4
		100	1095	1050	—4.1
25	C_4–CO_2	220	1090	1020	—6.4
		280	758	750	—1.1
28	C_5–CO_2	107	1148	1070	—6.8
		127	1228	1110	—8.8
		204	1441	1200	—16.7
41	Benzene–CO_2	104	1100	1060	—3.7
		122	1230	1260	2.4
		140	1420	1340	—5.6
44	C_3–CO_2	188	900	870	—3.3
		145	1470	1390	—5.4
		76	2180	2150	—1.4
3	CO_2–H_2S	200	1307	1305	—0.2
		166	1286	1270	—1.2
		135	1209	1213	0.3
		92	1077	1093	1.5

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J. M. Lenoir received his Ph.D. degree from the University of Illinois in 1949. He spent four years as an assistant and associate professor at the University of Arkansas, and two years at the University of Denver. He has been an engineer for American Oil Company, Texas City, and is presently associated with C F Braun and Company, Alhambra, Calif.

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Military Expects to Buy Less Fuel After 1959

Shift in aircraft engines expected to change demand from avgas to jet fuel.

Rear Admiral O. P. Lattu
Military Petroleum Supply Agency, Washington, D. C.

HERE IS a picture of the actual deliveries of military fuels from 1953 through 1957, the programmed procurement for 1958 and 1959, and estimates projected through 1963. These estimated requirements are for peacetime operations and predicated on currently approved programs; such as, phasing out certain types of reciprocating engine aircraft to be replaced by heavier and larger jet fuel-consuming turboprop and jet aircraft. These estimates may or may not agree with actual procurement, depending on the implementation of these plans, the availability of funds, changes in world conditions and other indeterminable factors. These factors have exerted an influence on forecasted requirements; not so much to materially change the trends, but possibly more to stretch out the time required for the indicated changes to take place.

Total U. S. military requirements will reach a peak in 1959, and then begin a slight downward trend. The somewhat high requirements in the fiscal year 1957 were caused by the Suez crisis in the fall of 1956.

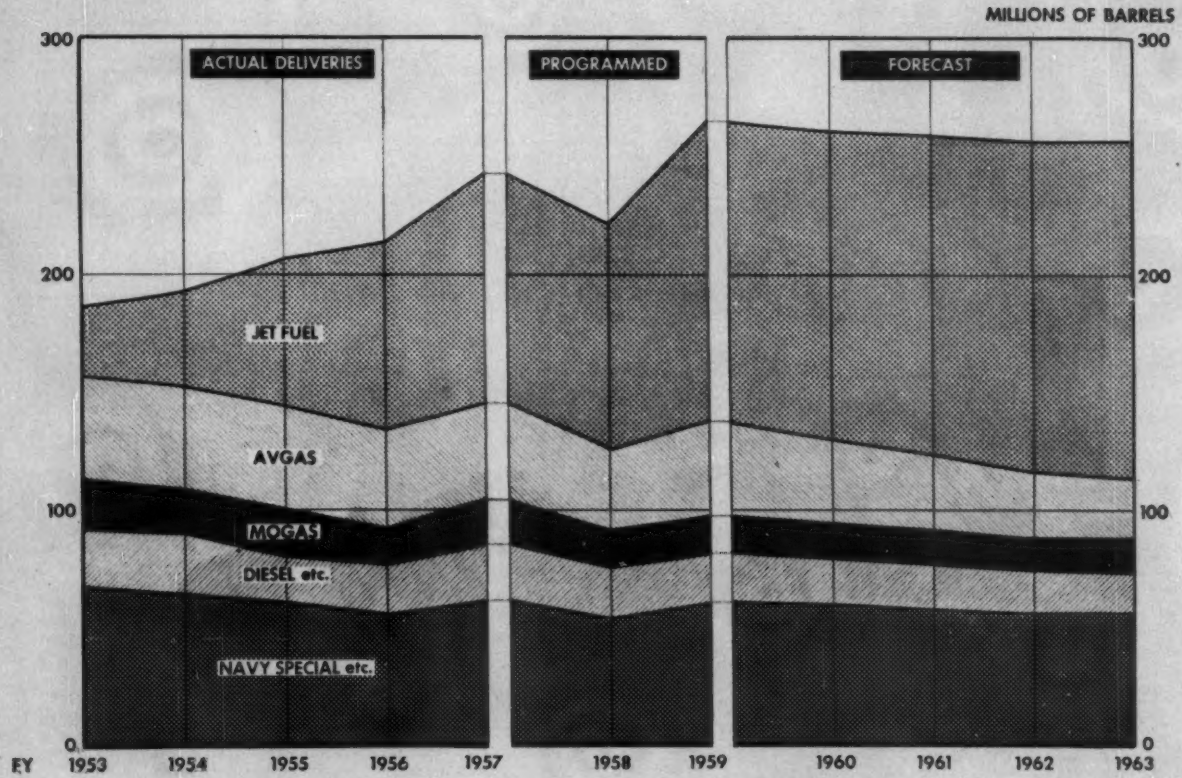
Rather than looking at the totals, perhaps the trends in specific products will be more significant. The chart shows jet fuel is still the major single fuel used by the military and has been since 1955. Total jet fuel required in 1963 will be an estimated 50 percent more than used in 1957, of which over 96 percent will be JP-4. However, in this same period JP-5 will jump 2.5 times.

Aviation gasoline reaches a peak in 1959 and then begins a gradual decline at an average rate of about 11 percent. Motor gasoline will continue to drop gradually, as will diesel, through 1963. Navy Special and other products will remain essentially constant.

In the face of these huge military requirements for petroleum, is there enough to go around? Large as these requirements seem to be, they nevertheless represent less than 8 percent of U. S. consumption and by 1962 will be an even smaller portion—less than 6 percent. Assuredly, the industry will have no problem in meeting these requirements.

An excerpt from a talk by Rear Admiral O. P. Lattu, executive director of the Military Petroleum Supply Agency, before a meeting of WPRA in Houston, February 7, 1958.

DELIVERIES BY INDUSTRY AND FORECASTED PROCUREMENT OF MAJOR FUELS



The military requirements are predicted on a fiscal year basis.

20 JANUARY 1958

Applied Hydrocarbon Thermodynamics

Part 3

Liquid and Vapor Densities

Wayne C. Edmister
California Research Corporation
Richmond, Calif.

LIQUID AND VAPOR densities are required in interconverting *volumetric* and *weight* rates of flow and for sizing fluid handling equipment. In addition, the changes of volume with temperature at constant pressure and with pressure at constant temperature are used to calculate the effect of pressure on the enthalpy and other thermodynamic properties. There is need for accurate compilations of fluid density for all types of chemical compounds. Charts for hydrocarbons are presented in this installment.

These data can be presented in three ways: (1) densities, (2) specific volumes, or (3) compressibility factors. Density and specific volume are inversely proportional to each other, while the compressibility factor is the ratio of real to perfect gas law volumes.

ρ = density in pounds/cubic foot or pounds/gallon

V = specific volume in cubic feet/pound

$$z = \frac{PV}{RT} = \frac{V}{RT/P} = \text{compressibility factor}$$

Specific volume (cubic feet/pound) versus temperature and pressure charts are presented for hydrocarbons. Liquid densities of light hydrocarbons in solution are also given. The material given in this part supplements and brings up to date the material given previously.[2]

Specific Volumes of Hydrocarbons. Specific volume has been given as functions of pressure and temperature.[3] Various generalizations were made to cover more hydrocarbons and wider conditions than the data used in preparing the plots. It is frequently preferable to use individual specific volume charts for the pure components. Such charts have been prepared for eight light hydrocarbons and are presented here as Figures 3.1 through 3.8.

Specific volume in cubic feet per pound is plotted on a log scale against temperature in °F. on the rectangular scale. Lines of constant pressure and the lines for saturated vapor and liquid are drawn on the diagrams. This same form was shown in Part VIII[2] as Figure 18, in which reduced parameters were used. Although not successful as a generalized plot, this form is most convenient for plotting specific volumes against temperature.

These charts (Figure 3.1 through 3.8) were constructed from data compiled by others.[1, 4, 5] The Mollier (log P versus H) diagrams developed at the Kamerlingh-Onnes Laboratory in Leiden, Holland, for the first seven hydrocarbons (methane through n-butane) were the source of most of the data for these hydrocarbons. A similar diagram prepared at Carnegie Institute of Technology for n-pentane was used in plotting Figure 3.8 for n-pentane.

Taking specific volume data off the log P versus H Mollier diagram for the construction of these plots involved making readings of temperature and volume at each pressure. Since both T and V are parameters, interpolation and smoothing were necessary. In a later installment, these Mollier charts will be presented and discussed.

At this point it is sufficient to point out that these P-V-T data are the result of careful derivations from experimental data. They are consistent and cover wide ranges of temperature and pressure and hydrocarbons. These Mollier diagram values were supplemented by readings from tables of specific volumes for saturated vapors and liquids.[4]

Liquid Densities of Light Hydrocarbons in Solutions. In making material balances for hydrocarbon mixtures, it is frequently necessary to convert from barrels per day to pounds per hour or vice versa. As liquid volumes are measured at 60 F., the density of the individual hydro-

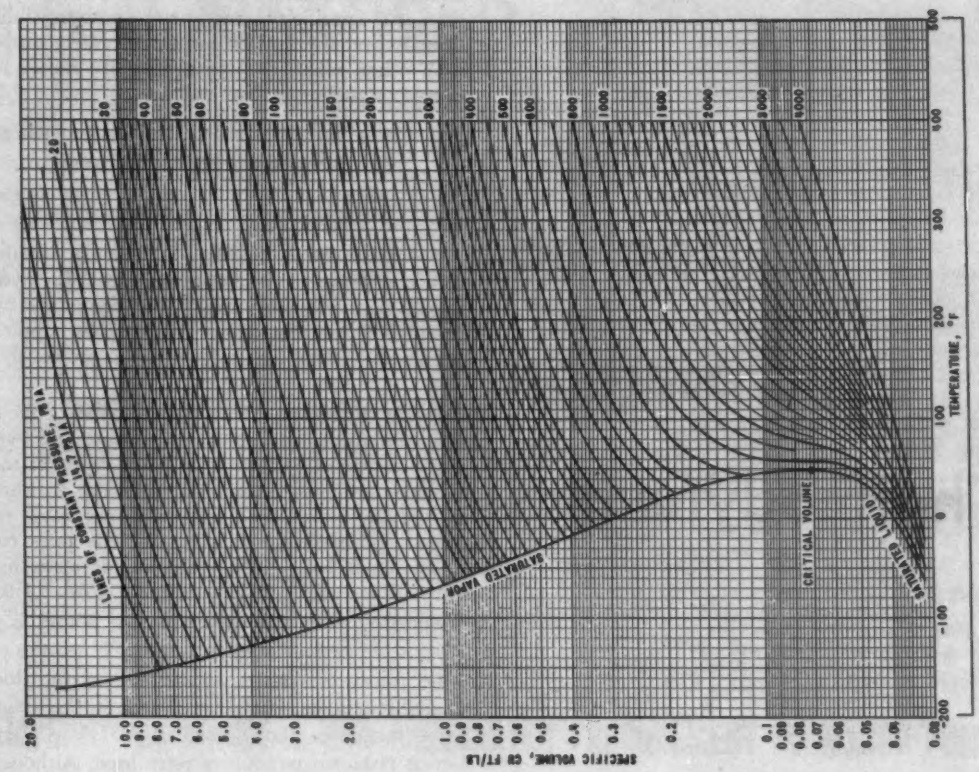


FIGURE 3.2—Specific Volume of Ethylene.

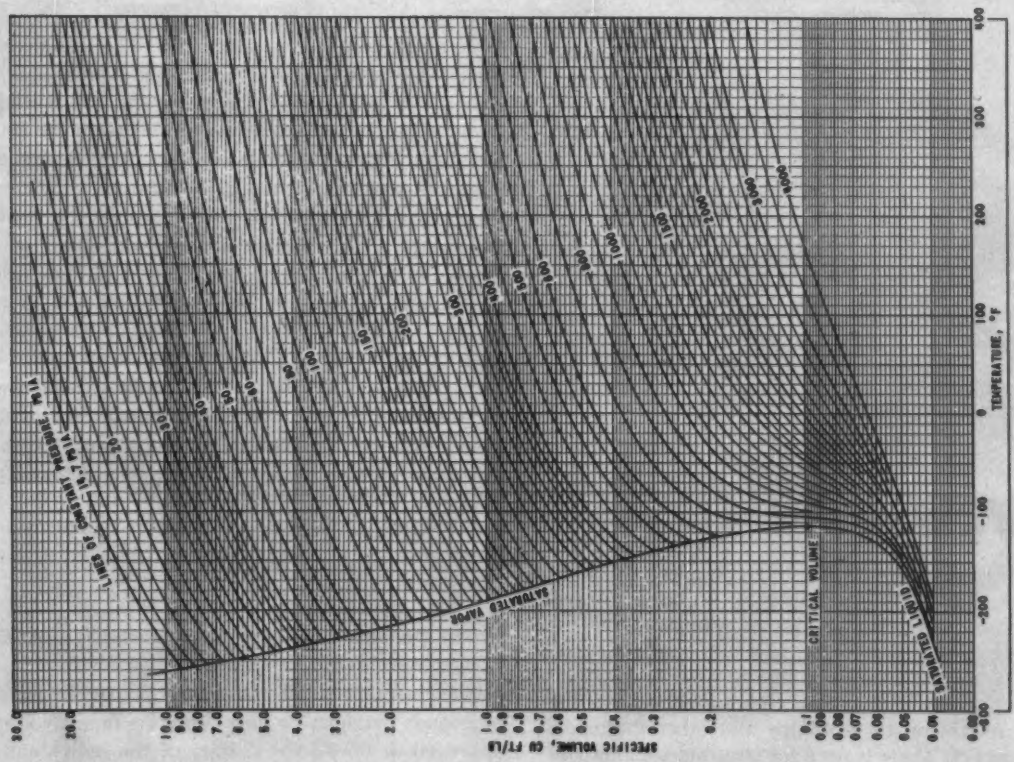


FIGURE 3.1—Specific Volume of Methane.

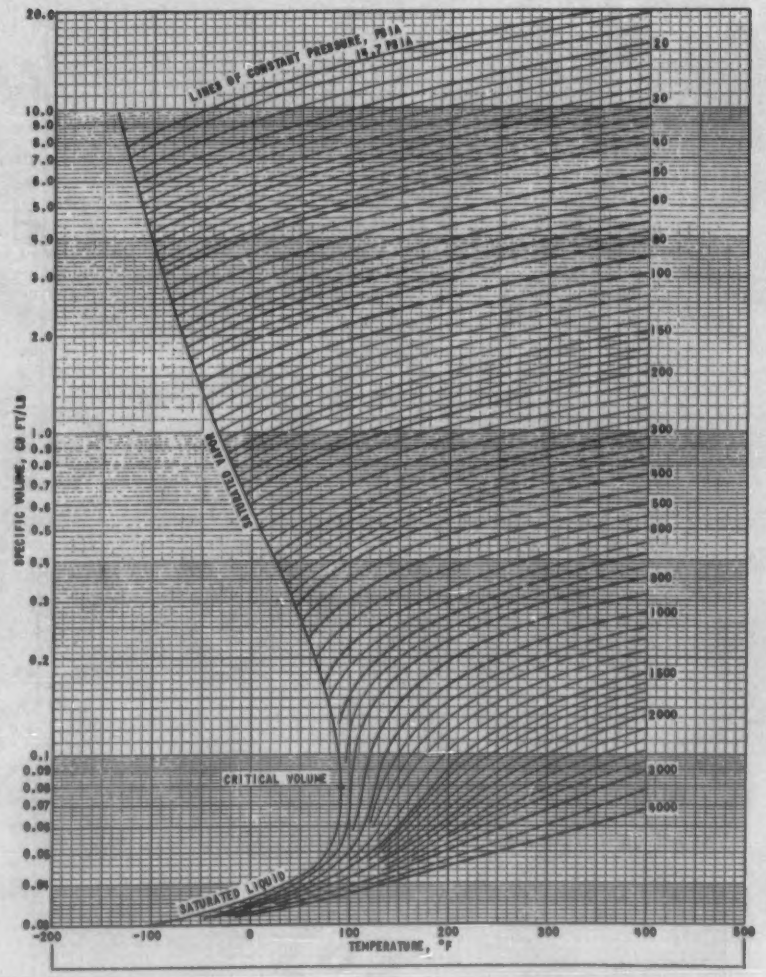


FIGURE 3.3—Specific Volume of Ethane.

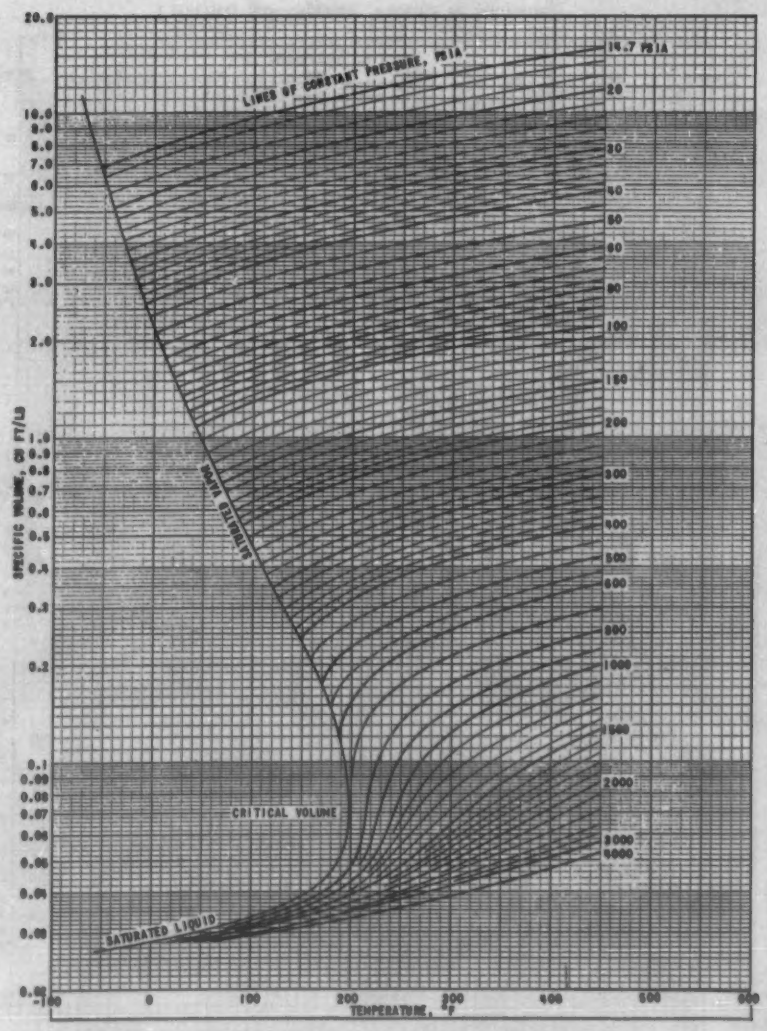


FIGURE 3.4—Specific Volume of Propylene.

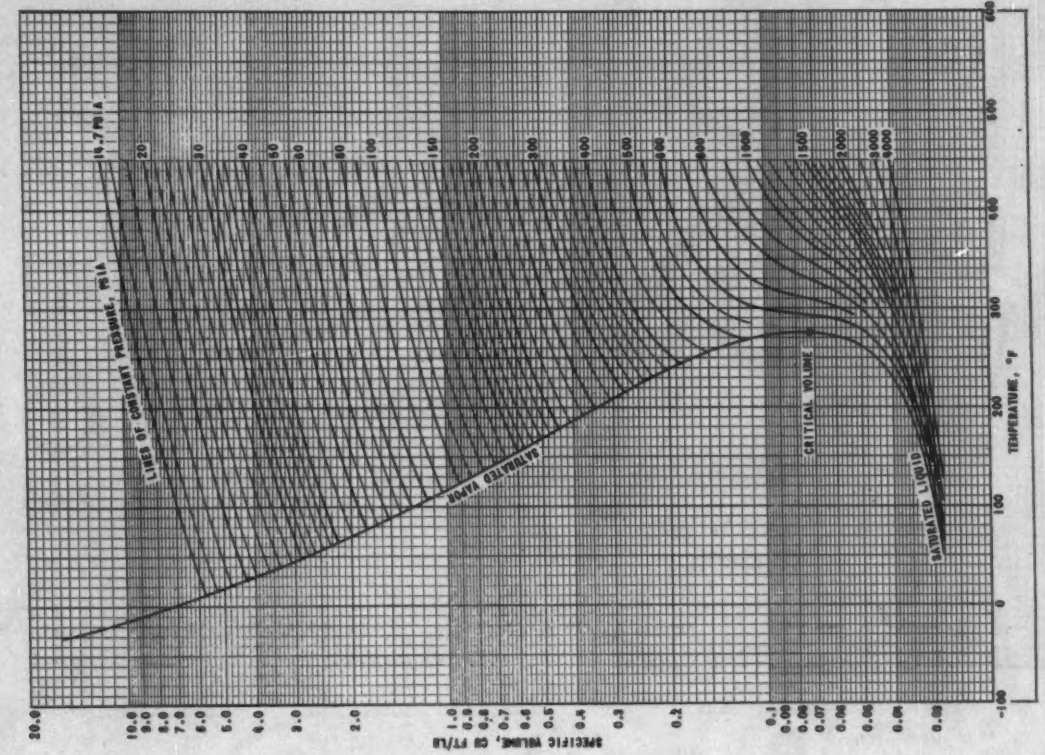


FIGURE 3.6—Specific Volume of i-Butane.

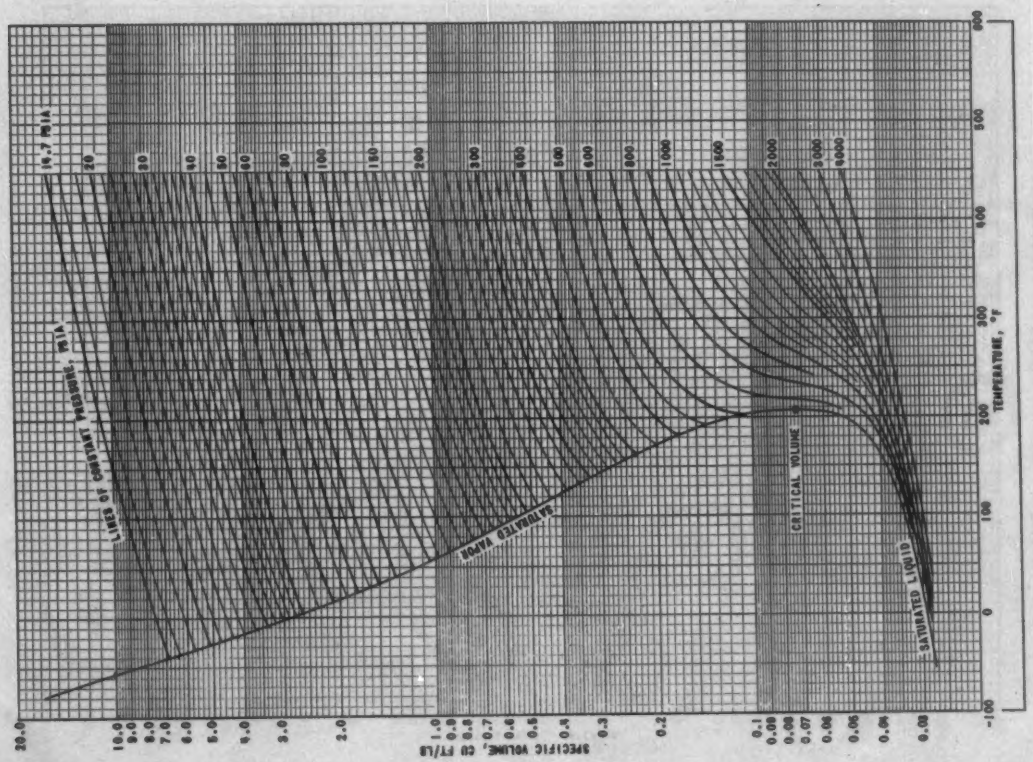


FIGURE 3.5—Specific Volume of Propane.

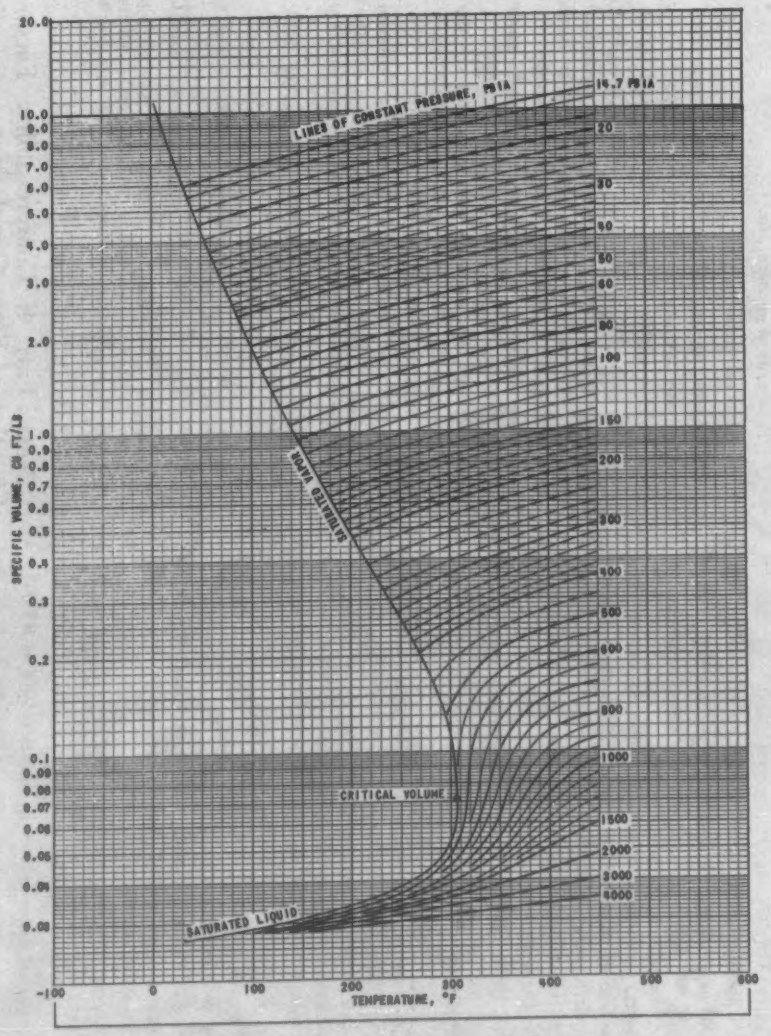


FIGURE 3.7—Specific Volume of n-Butane.

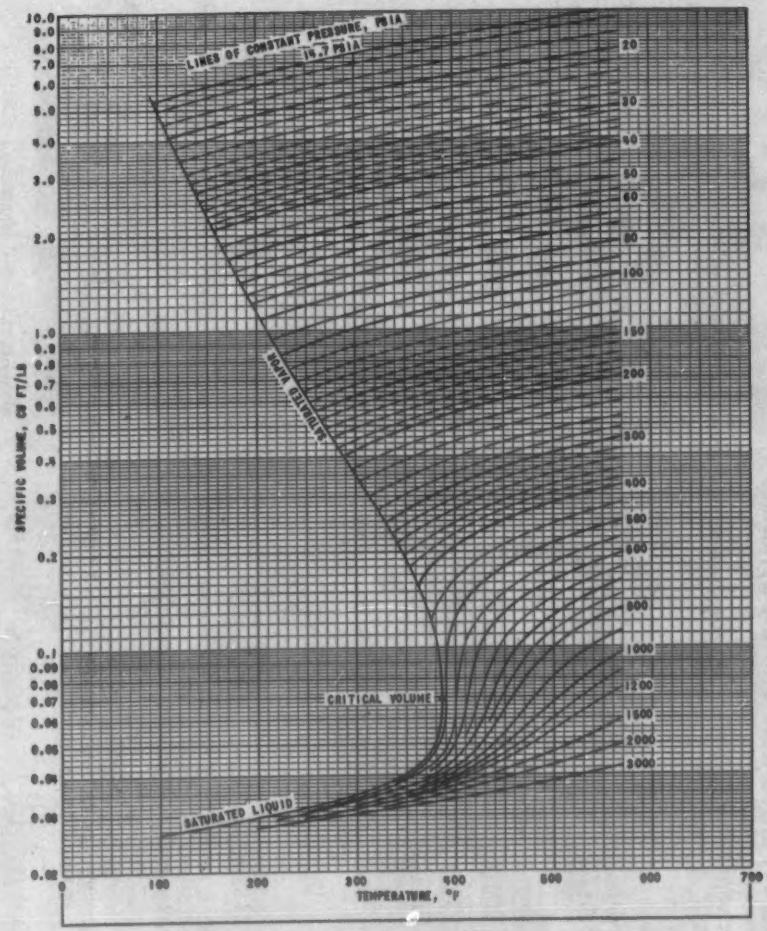


FIGURE 3.8—Specific Volume of n-Pentane.

TABLE 3.1—Conversion Factor A in Liquid Volume Conversion At 60 F

Hydrocarbon	"Observed" A From Sp. Gr. 60/60	Critical Pressure Pc psia	Mole Weight	VALUES OF C_A		$\left(\frac{\delta \ln \bar{f}/P^\circ x}{\delta P_r}\right)_{B_r, T_r}$ Eqn 3.4 (See Note)	Calc "A" Eqn 3.3
				$C_A = \frac{A}{(P_c)(MW)}$	Smoothed and Extrapolated		
Hydrogen	....	306*	2.0	.....	0.000300	0.1400	0.184
Methane	....	673	16.0	.....	0.000275	0.1520	2.96
Ethene	....	742	28.1	.....	0.000273	0.1525	5.70
Ethane	....	708	30.1	.....	0.000272	0.1540	5.80
Propene	7.59	667	42.1	0.000270	0.000271	0.1545	7.60
Propane	7.39	617	44.1	0.000272	0.000270	0.1550	7.40
i-Butane	8.20	529	58.1	0.000266	0.000267	0.1570	8.20
n-Butane	8.51	551	58.1	0.000266	0.000266	0.1575	8.52
n-Pentane	9.19	489	72.1	0.000260	0.000261	0.1605	9.20
n-Hexane	9.67	440	86.2	0.000255	0.000255	0.1640	9.67

* Critical Pressure plus 8 Atmospheres (as recommended by Newton[6] to make H_2 fit generalized f/p correlation).

Note: From Eqn 3.4: $\left(\frac{\delta \ln \bar{f}/P^\circ x}{\delta P_r}\right)_{B_r, T_r} = \frac{0.2335}{(10.71)(520)C_A} = \frac{0.000419}{C_A}$

carbons at 60 F. is used in this conversion calculation.

The conversion factor is defined as follows:

$$A = \frac{\text{pounds/hour}}{\text{barrels (42 gallons)/day}}$$

In terms of specific gravity:

$$A = (8.33)\left(\frac{42}{24}\right) \times (\text{sp gr}) = 14.57 \times (\text{sp gr})$$

In terms of pounds/gallon:

$$A = \left(\frac{42}{24}\right)(\text{pounds/gallon}) = 1.75 \times (\text{pounds/gallon})$$

where: sp gr = specific gravity 60/60

pounds/gallons = density in pounds per U. S. gallon at 60 F.

Using these "A" factors assumes additive volumes.

Hydrogen, methane, ethene, and ethane cannot exist alone as liquids at 60 F. so their "A" factors must be determined in some other way than from the pure liquid density at 60 F. The thermodynamic relationship between the fugacity and partial volume suggests a method for finding these factors, as follows:

$$\bar{V} = RT\left(\frac{\partial \ln \bar{f}/x}{\partial P}\right)_{T, \text{comp.}} \quad (3.1)$$

Fugacity coefficients were recently[5] generalized in a correlation using three reduced parameters, T_r, P_r, and B_r. The last of these three is the boiling point ratio (i.e., molar average boiling point of mixture divided by component boiling point) is a composition-effect parameter.

In this previous[5] correlation, the ratio $\bar{f}^L/P^\circ x$, where P° is the vapor pressure, was correlated. This is a dimensionless activity coefficient.

In terms of these reduced parameters and the liquid phase activity coefficient, Equation (3.1) for partial molar volume becomes,

$$\bar{V} = \frac{RT}{P_c}\left(\frac{\partial \ln \bar{f}^L/P^\circ x}{\partial P_r}\right)_{T_r, B_r} \quad (3.2)$$

where $\bar{V}$ = partial molar volume in the same units as RT_c/P_c

The conversion factor "A" may also be found from the partial molar volume (assumed to be in cubic feet/pound mole units), as follows:

$$A = \left(\frac{8.33}{62.4}\right)\left(\frac{42}{24}\right)\frac{M}{\bar{V}} = 0.2335\,\frac{M}{\bar{V}}$$

combining with Equation (3.2) gives,

$$A = (C_A)(P_c)(M) \quad (3.3)$$

where:

$$C_A = \frac{0.2335}{RT}\left(\frac{\partial \ln \bar{f}^L/P^\circ x}{\partial P_r}\right)^{-1}_{T_r, P_r} \quad (3.4)$$

P_c = critical pressure, psia

M = molecular weight

The first pressure derivative of the logarithm of the liquid phase activity coefficient can be found from plots of $\ln \bar{f}^L/P^\circ x$ versus P_r at constant T_r and B_r.

At this point, Equation (3.3) will be used to extrapolate "A" values for the higher boiling hydrocarbons to estimate "A" values for the lighter ones in liquid solution. Values of C_A are first found for several hydrocarbons from observed "A" values at 60 F. and values of P_c and M by Equation (3.3). Then these values of C_A were smoothed and extrapolated, and values of the derivative were computed. These were found to decrease almost linearly with decreasing molecular weight.

Values of "A" were next computed by Equation (3.3) and tabulated. In this way liquid solution density factors shown for the four light gases were found. See Table 3.1.

ACKNOWLEDGMENT

W. S. Hanna prepared the charts.

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[5] Keesom, W. H., Bijl, A., and Monte, L. A. J., J. App. Sci. Res., Vol. 4, Sec. A, p. 261 (1952).

[6] Newton, R. H., Ind. Eng. Chem., 27, 302 (1935).

Next, Part 4: Compressibility Factor and Equation of State Correlations.

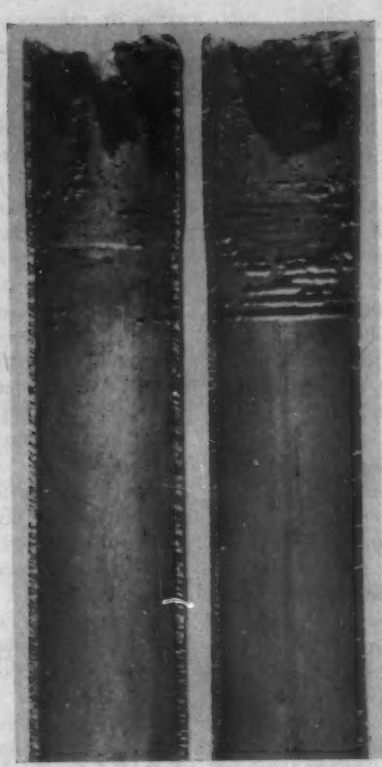

FIGURE 1—Scratch lines near the tube ends were not able to develop their natural protective film nor was there sufficient galvanic protection. Result: corrosion.

Cathodic Protection May Boost Corrosion!

In the case of non-ferrous alloys, service results show cathodic protection could be harmful to exchanger tubes.

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Leeds, England

THERE IS an increasing use of cathodic protection by means of both sacrificial anodes and impressed current. It is undoubtedly keeping the corrosion of iron and steel pipe lines and other structures in check. Care needs to be exercised, however, in extending the use of this type of protection to insure that the results obtained are not in fact the opposite of that which was desired. This is particularly true in the case of the non-ferrous alloys usually used for heat exchanger work; for example, the condensers in steam generating stations, and the coolers, condensers, etc. in oil refineries. Service results have frequently shown that cathodic protection could be detrimental to the tubes in this type of application. In some instances, the change when the zinc or magnesium anodes have been replaced by iron has been spectacular and in other applications, particularly in some oil refineries, careful observations over long periods on a statistical basis have shown that without doubt the best results were obtained using large iron anodes.

Non-Ferrous Anodes. There appear to be two main ways in which "protective" galvanic effects can be detrimental to the service life of non-ferrous tubes. Non-ferrous alloys which resist impingement attack in turbulently flowing sea water do so because of the protective films which form on the tube surface. These are usually hydrated oxide films. The improved performance of aluminium brass in relation to 70/30 brass, for example, is due to the presence of alumina in the surface film. In the case of the cupro-nickel alloys, it is well known that the strength and suitability of the film is also affected by minor alloying constituents, e.g. iron and manganese. Therefore, if a tube is made cathodic to a sacrificial anode such as magnesium, there is the danger that the formation of the natural protective film will be prevented at those portions of the tube within the sphere of action of the anode where the surface is cathodic and where reducing rather than oxidizing conditions prevail.

Areas within a short distance of the tube ends will be so affected and these are, of course, the very positions where there is the greatest turbulence and therefore susceptibility to impingement attack. Cases have been

observed where corrosion has occurred a short distance from the inlet end on scratch lines, etc. which strongly suggests that, at this point, the newly scratched metal was affected by the sacrificial anodes in such a way that it was not able to develop its naturally protective film in a normal manner and yet was not sufficiently well protected, galvanically, to prevent corrosion.

A case of this kind is illustrated in Figure 1. This is a 70/30 cupro-nickel tube which was expanded into the tube plates at each end during which operation the inside surface was lightly scratched by the tail of the expanding tool a short distance from the inlet end. The condenser was fitted with zinc protection blocks, and, as often happens, new zinc blocks were fitted at the same time as the new tubes. As can be seen from the photograph, serious corrosion has taken place on these light scratches. The spiral corrosion groove, being white and free from corrosion products with the surface between the scratches almost unaffected, presented a rather unusual appearance when viewed in the condenser.

The opinion of the author is that this corrosion has occurred as a direct result of the presence of sacrificial anodes. When a surface is scratched in this way and the tube goes into service with new zinc or magnesium anodes, there will be a large potential difference between the anodes and the newly scratched surface tending to prevent natural protective film formation.

However, the effect of galvanic protection falls off rapidly as the distance from the tube end increases. The portion of the tube which is most likely to be damaged on installation (a short distance from the inlet end) is also that which is most likely to be insufficiently far away to be able to develop a natural protective oxide film and yet not sufficiently near the end to be fully and continuously protected cathodically. Iron or steel anodes do not appear to have the same undesirable effects.

Ferrous Anodes. The second way in which adverse effects may be caused arises from the fact that iron compounds in the cooling water, particularly in the ferric state, undoubtedly have a beneficial effect on the corrosion resistance of most copper base alloys. This suggests that in some way the iron reinforces and strengthens the protective film. A related observation is the effect of adding iron to copper-nickel alloys. The corrosion resistance of these alloys is now well known to be far more dependent on the iron content of the alloys than on the nickel content. Beneficial results from iron corrosion products in the cooling water have also frequently been observed.

One of the earliest references to this was made over 30 years ago[1] when it was stated that at Carville power station the number of failures was greatly reduced by the addition of iron oxide to the cooling water, and that the corrosion of condenser tubes was virtually eliminated. If, therefore, the corrosion of iron or steel parts in the system is prevented by cathodic protection, the mere absence of these corrosion products may in some circumstances give rise to less satisfactory conditions for good tube life.

The installation of sacrificial iron anodes of large areas will, of course, overcome this problem and this has undoubtedly improved the service life of the tubes in many cases. The author is aware of no case where the galvanic effects of iron or steel have been harmful. Whether this is because the potential is lower than with zinc or magnesium, or because iron compounds are produced, or because of a combination of both these effects, is not known.

This type of result was well illustrated in the case of a vessel which was tubed with aluiminium brass in 1931. This vessel continued to operate until after the last war when it was damaged by fire when being refitted. Samples of the condenser tubes were removed for examination and it was obvious that these were completely unaffected by corrosion and, as they had been fitted by packing at each end, the original tubes were removed and used again when the condenser was rebuilt.

Six months after resuming service it was noticed that on some of the tubes there were signs of corrosion on scratch marks near the inlet ends. It was then realized that during the rebuilding of the condenser, the water box had been rubberized so that iron corrosion products had been largely eliminated from the cooling water. The corroded areas on the tubes healed over and became covered with a dark brown film shortly after iron plates had been fixed in the water box.

Exchanger Tube Protection. Summarizing the position, the evidence from a large number of practical installations in widely different conditions shows conclusively that sacrificial iron anodes are the best material to use for the protection of copper alloy heat exchanger tubes. The high potential available from zinc or magnesium electrodes may give rise to conditions where the natural protective films do not form, and such anodes are also likely to deprive the tubes of the beneficial effects of iron corrosion products in the water. From the same viewpoint, where it is intended to install an impressed current system of "protection," risk of damage to the tubes would be minimized by using soluble iron anodes rather than insoluble anodes, even though more frequent replacement of anodes would be necessary. When the tubes are new it would also be advisable either to operate for a time without any current, or at least to reduce the potential on the anodes to a very low figure, for a period.

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About the Author

Clifford Breckon is the director and chief metallurgist at The Yorkshire Copper Works, Ltd., Leeds, England, where he has spent all his working life. He obtained his B.S. degree in 1936 as an external student of London University. He is particularly interested in problems affecting the use of non-ferrous tubes in heat exchangers.

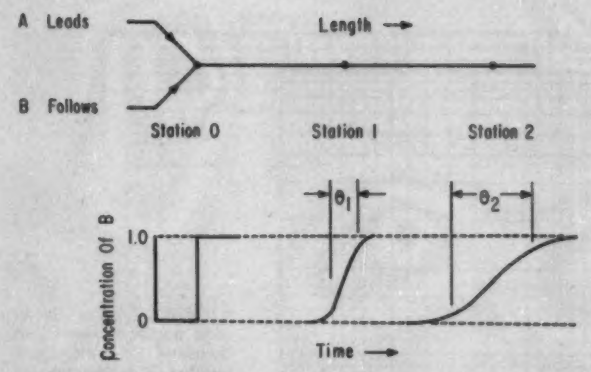

FIGURE 1—When one fluid (A) is followed by another (B) there is a zone of mixing. The time (Θ) for this zone to pass a point is proportional to the contamination width.

How Much Mixing Occurs in a Pipe?

Here are charts to predict the contamination which will exist if the two fluids are pumped successively through the same transfer line.

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WHEN PRODUCTS are moved around the refinery, one line can be used to handle a variety of materials. These materials are transported successively, and switching from one to another forms a zone of contamination between the two. The effect of mixing in a pipe line is shown schematically in Figure 1.

With charts presented in this report, the zone of contamination is related to a dispersion number and the pipe dimensions. The dispersion number in turn is obtained from a correlation with Reynolds numbers.

The over-all design aspects are not considered here. Refer to Birge[1] for these.

Turbulent flow gives the correlation of dispersion numbers with Reynolds numbers as shown in Figure 2. For Reynolds numbers above 10,000 the theoretical curve is shown and it brings together much data from the laboratory and the field for both gases and liquids. Pipe sizes varied from 0.02 to 40 inches in diameter and lengths as great as 400 miles were used. As the Reynolds number is progressively decreased below 10,000, however, the one experimental study in this range to date shows an increasing deviation from the theoretical curve. This may be expected for in the development of the theory the laminar sublayer is ignored and it is precisely in this region ($Re < 10{,}000$) that the sublayer becomes appreciable in thickness. This may result in the additional contribution of molecular diffusion in the sublayer as a means of axial transport.

Streamline flow is of little interest in product pipe line design. In this region of flow the zone of contamination is much greater than with turbulent flow. However, the correlation of dispersion number for streamline flow is shown in Figure 3. Here molecular diffusion plays a significant role in product contamination.

For short pipe the diffusion mechanism is not applicable. Figure 3 should be used only when the following condition is fulfilled:

$$(Re)\ (Sc) << 30\,\frac{L}{d}$$

The few data available check these theoretical predictions.

The contaminated zone as related to the system variables is shown in Figure 4. The method used for preparing this figure is described in the accompanying box. The following problems illustrate the various uses of these charts.

ILLUSTRATIVE PROBLEMS

In these problems *A* refers to the leading fluid and *B* refers to the following fluid in a 12-inch ID pipe. Stations 1 and 2 are 10,000 and 100,000 feet downstream from Station 0, the point of feed origin as shown in Figure 1.

Problem 1—If at Station 1 the 10%-90% contaminated width is 500 feet find the 1%-99% contamination width and the 10%-99% contaminated width at that station (10%-99% contamination means allowing up to 10% of *B* in *A* but only allowing 1% of *A* in *B*).

Solution—The fraction contaminated

$$F_{10\text{-}90} = 500/10{,}000 = 5 \times 10^{-2}$$

From Figure 4 this corresponds to

$$D/uL = 1.9 \times 10^{-4}$$

Using this value of D/uL we find from Figure 4 that for a 1%-99% contamination

$$F_{1\text{-}99} = 9.2 \times 10^{-2}$$

therefore the contamination width

$$W_{1\text{-}99} = (9.2 \times 10^{-2})\ (10^4) = 920\ \text{ft.}$$

To find the 10%-99% contaminated width we proceed as follows:

$$W_{10\text{-}99} = W_{10\text{-}50} + W_{50\text{-}99}$$

But as the S-shaped contamination curve is symmetrical in this region ($D/uL < 0.01$)

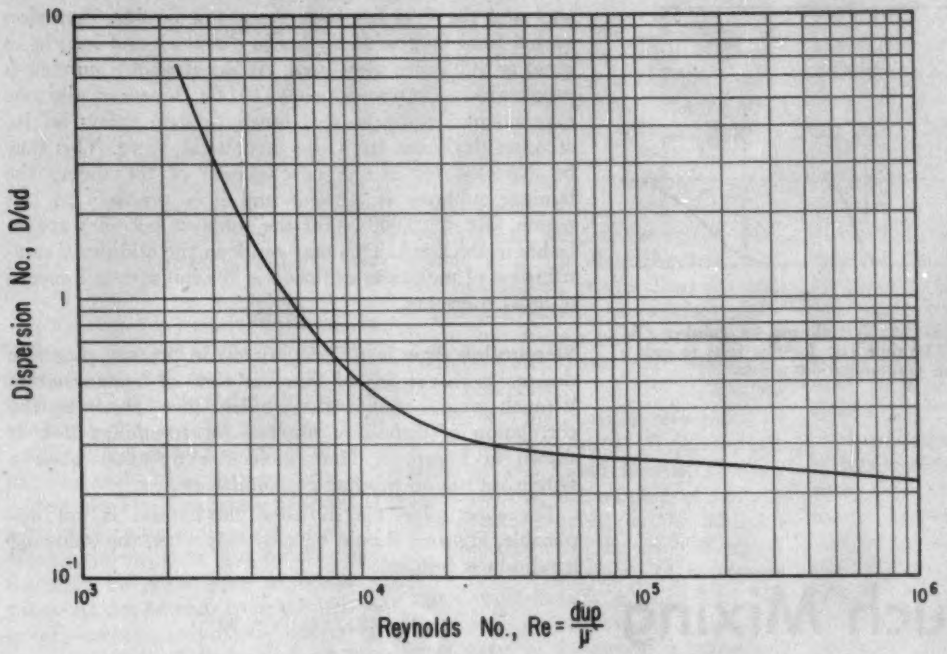

FIGURE 2—For Reynolds numbers above ten thousand the dispersion number is a function of the Reynolds number. Here is the relation for this turbulent region of flow.

$$W_{10-90} = \frac{W_{10-90}}{2}$$

and

$$W_{90-90} = \frac{W_{1-90}}{2}$$

therefore

$$W_{10-90} = \frac{1}{2}(W_{10-90} + W_{1-90})$$

$$= \frac{1}{2}(500 + 920) = 710 \text{ ft.}$$

Problem 2—If at Station 1 the 10%-90% contaminated width is 500 feet find the 10%-90% contaminated width at Station 2.

Solution—The fraction of pipe line which is 10%-90% contaminated at Station 1 is

$$F_{10-90} = 500/10{,}000 = 5 \times 10^{-2}$$

From Figure 4 at Station 1

$$(D/uL)_1 = 1.9 \times 10^{-4}$$

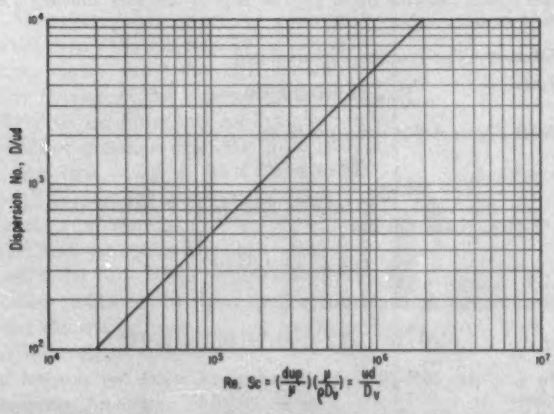

FIGURE 3—Here is the chart for getting the dispersion number for streamline flow. It is only applicable when (RE) (Sc) $<<$ 30 $\frac{L}{d}$.

For constant flow conditions D and u remain unchanged, therefore for Station 2

$$(D/uL)_2 = (D/uL)_1(L_1/L_2) = 1.9 \times 10^{-4}(10^4/10^6) = 1.9 \times 10^{-6}$$

And again from Figure 4 but for Station 2, the fraction of pipe line contaminated

$$(F_{10-90})_2 = 1.6 \times 10^{-2}$$

Hence, the 10%-90% contaminated width at Station 2

$$(W_{10-90})_2 = (F_{10-90})_2 \cdot L_2 = (1.6 \times 10^{-2})\ 10^5 = 1600 \text{ ft.}$$

Note—In general for small D/uL (D/uL < 0.01) the contaminated width varies as the 0.5 power of the pipe length as may be seen by the slopes in Figure 4. For example, if the length of the pipe line were increased 16 times the contaminated width would increase by a factor of 4.

Problem 3—If at Station 1 the contaminated width is 500 feet for flow in a 12-inch ID pipe what would it be in a 3-inch ID pipe for the same Reynolds number?

Solution—The Reynolds number is constant hence D/ud is unchanged. But

$$(D/uL) = (D/ud) \cdot (d/L)$$

Hence

$$(D/uL)_{3''\text{pipe}} = \frac{1}{4}(D/uL)_{12''\text{pipe}}$$

And from Figure 4

$$F_{3''\text{pipe}} = \frac{1}{2}F_{12''\text{pipe}}$$

Therefore the contaminated width for the 3-inch pipe,

$$W = 250 \text{ ft.}$$

Problem 4—If at Station 2 the average Reynolds number of the two fluids is 10,000, find the 10%-90% contaminated width.

Solution—

From Figure 2

$$(D/ud) = 0.4$$

Therefore

$$(D/uL) = (D/ud) \cdot (d/L) = (0.4) \cdot \left(\frac{1}{10^5}\right) = 4 \times 10^{-6}$$

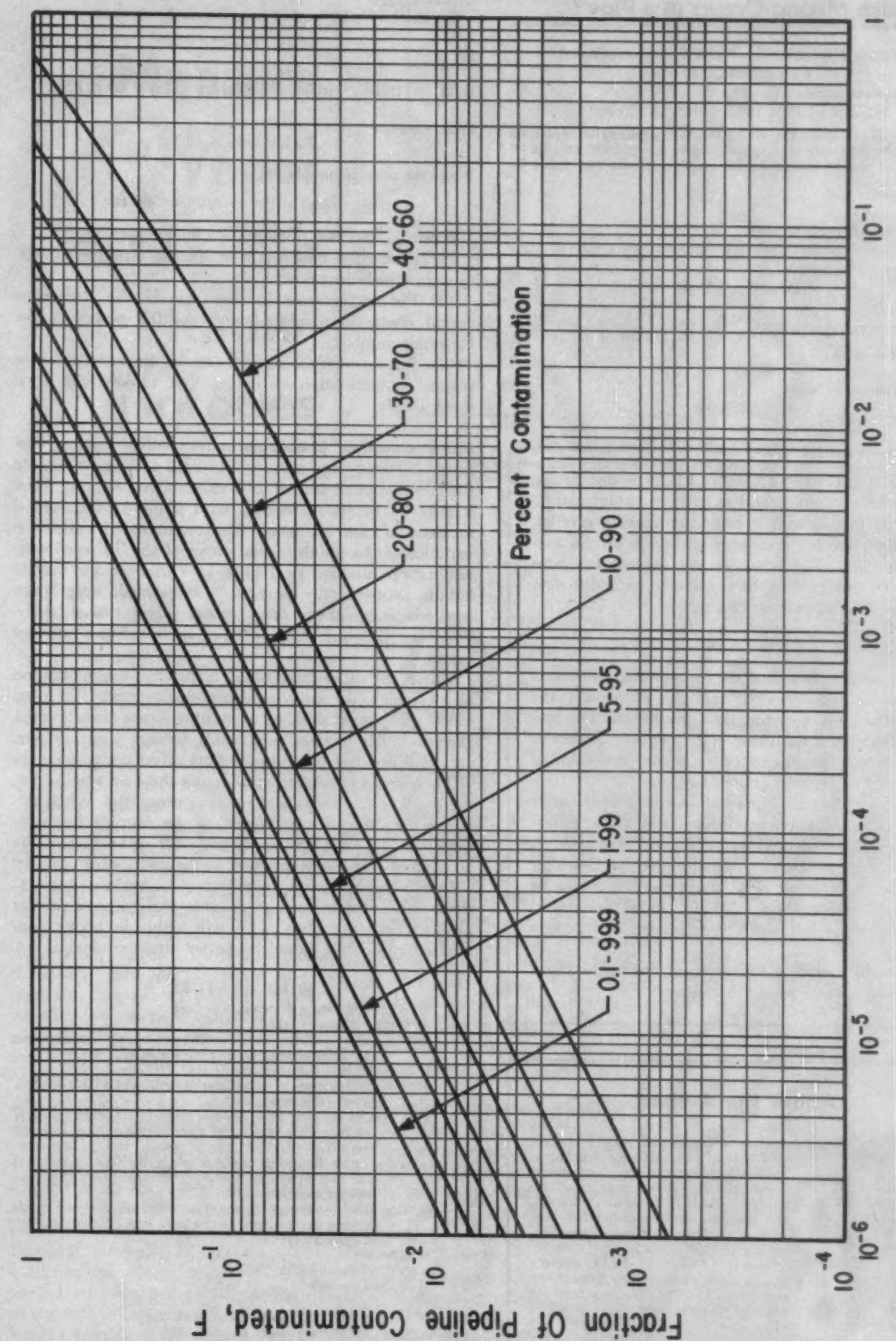

FIGURE 4—The example problems bear out that streamline flow results in much greater contamination than turbulent flow.

How Much Mixing Occurs in a Pipe? . . .

And from Figure 4 the fraction of pipe line contaminated

$$F_{10\text{-}90} = 7.26 \times 10^{-3}$$

Therefore the contaminated width

$$W_{10\text{-}90} = (7.25 \times 10^{-3}) \cdot (10^5) = 725 \text{ ft.}$$

Problem 5—How would the above found contaminated width be affected if the flow rate is changed to give Re = 1000 and Re = 100,000? Let the average Schmidt number of the two fluids be taken as 385.

Solution—

For the case where Re = 1000

$$(Re) \cdot (Sc) = (1000) \cdot (385) = 3.85 \times 10^5$$

From Figure 3 extrapolated

$$(D/ud) = 2 \times 10^3$$

Therefore

$$(D/uL) = (D/ud) \cdot (d/L) = (2 \times 10^3) \cdot \left(\frac{1}{10^5}\right) = 2 \times 10^{-2}$$

And from Figure 4

$$F_{10\text{-}90} = 0.5$$

So the contaminated width,

$$W = 50{,}000 \text{ ft.}$$

PRODUCT CONTAMINATION is due to the axial mixing of fluids and as such its extent can be predicted theoretically considering velocity profiles, molecular transfer and eddy transport of the material in flow. The result of the analysis indicates that axial mixing may be considered as a diffusion mechanism governed by Fick's Law

$$\frac{dc}{d\Theta} = D\Delta^2 c$$

The constant D, called the longitudinal dispersion coefficient, depends on the fluid properties, the physical set up and the flow conditions. For any given situation if the value of D is known the above equation may be integrated to allow prediction of the extent of product contamination.

For this report the equation was integrated under appropriate boundary conditions to yield the differential of the S-shaped curve shown in Figure 1. This differential curve approximates the Gaussian error curve for small Du/L (straight line region of Figure 4, or for $D/uL < 0.01$), its variance and standard deviation were determined to prepare Figure 4.

Fuller discussion, justification of the method and references may be found elsewhere.[2]

About the Author

Octave Levenspiel is an associate professor of chemical engineering at Bucknell University, Lewisburg, Penn. He was born in China, attended schools in Germany, Britain, and France, and obtained his B.S. degree in chemistry from the University of California in 1947. He received his M.S. and Ph.D. degrees in chemical engineering from Oregon State College. He has been at Bucknell for the past three years.

For Re = 100,000 we find from Figure 2

$$D/ud = 0.26$$

Then

$$D/uL = (D/ud) \cdot (d/L) = (0.26) \cdot \left(\frac{1}{10^5}\right) = 2.5 \times 10^{-6}$$

From Figure 4

$$F_{10\text{-}90} = 5.86 \times 10^{-3}$$

Hence the contaminated width,

$$W = (5.86 \times 10^{-3}) \cdot (10^5) = 586 \text{ ft.}$$

From the last two problems we may generalize:

(1) Streamline flow results in much greater contamination than turbulent flow.

(2) For an increase in flow rate in the streamline region contamination rises with the 0.5 power of the Reynolds number.

(3) For an increase in flow rate in the turbulent flow region contamination decreases, first rapidly and then more slowly.

More complex problems may involve varying flow rates, different pipe sizes in the line, adding waste into the contaminated section as it passes a station, etc. Then it may be necessary to deal with a more fundamental measure of the width of the contaminated zone—the variance of the differentiated curve of the S-shaped contamination function of Figure 1. Variances are easy to handle as they may be added, subtracted, etc., hence methods using them may be developed rather easily. Pertinent literature references may be found in a previous report.[2]

There are still many factors in product contamination about which we know embarrassingly little. We need much more good data to accurately locate these curves. We would like to know how bends, fittings, pumps, filters, etc., and non-full pipe gravity flow affect contamination.

Theory was developed considering the lead and following fluids to have identical physical properties. When this is not the case what is meant by the average Reynolds number? We have arbitrarily picked it to be that of the 50 percent-50 percent mixture. But is this the best choice?

Only when the many contributing factors are quantitatively accounted for will we be able to accurately predict product contamination. This will result in better contamination control as well as better pipe line design.

NOMENCLATURE

- c = concentration of product in fluid
- d = pipe diameter (ft.)
- D = longitudinal dispersion coefficient which characterizes the axial mixing in flowing fluids (ft.²/sec.)
- D_v = molecular diffusion coefficient (ft.²/sec.)
- F = W/L fraction of pipe line length which is contaminated (dimensionless)
- L = length of pipe line, always considered from point of product introduction to distribution station in question (ft.)
- $Re = du\rho/\mu$, — Reynolds number of 50%-50% mixture of the two products flowing successively in the pipe line (dimensionless)
- $Sc = \mu/\rho D_v$, — average Schmidt number of the two fluids flowing successively in the pipe line (dimensionless)
- u = fluid velocity (ft./sec.)
- Θ = time
- ρ = fluid density (lbs./ft.³)
- μ = fluid viscosity (lbs./ft. sec.)

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Measure Vapor Losses with Radio-isotopes

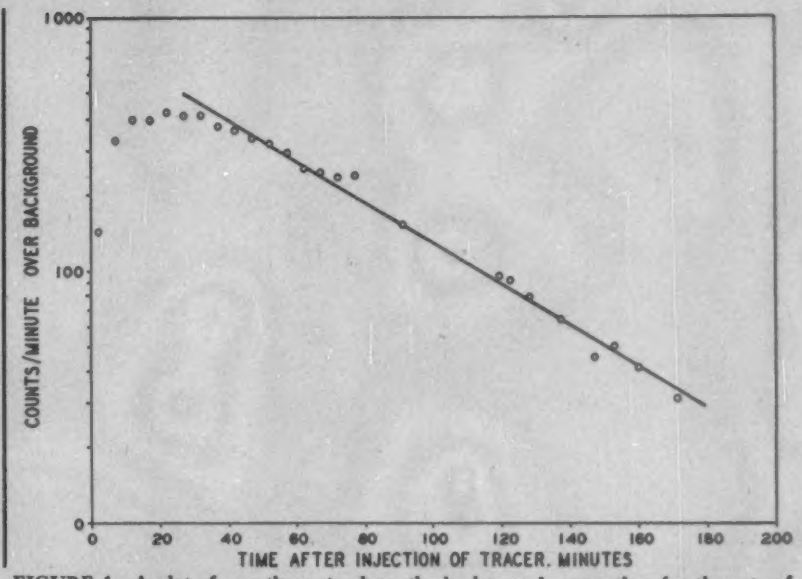

FIGURE 1—A plot of counting rate above the background versus time for the rate of air loss from the oil-water separator.

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ONE OF THE problems encountered in air pollution control is that of determining the quantities of vapors or gases lost from unsealed enclosures. Examples of such enclosures include the air spaces above water-oil separators, unsealed storage tanks, and structures around operating equipment. It is generally possible to determine the composition of gases escaping from enclosed spaces by conventional methods, but measurement of gas displacement rates is normally quite difficult. A method for measuring rates of gas losses from confined spaces has been developed wherein the loss of a radioactive gas is used as an indication of total gas loss.

The method consists, basically, of determining the rate of disappearance of a radioactive tracer from the enclosed space under study. A radioactive gas or vapor is added to the space, and the concentration of radioactive material is measured as a function of time by conventional counting methods. By plotting the concentration of radioactive materials against time, a slope proportional to the rate of loss is obtained. Knowing the volume of the enclosed space and the displacement rate, one can calculate the volumetric rate of loss.

Example. What's the rate of loss of hydrocarbons to the air from the air space of an oil-water separator? The air space was covered with close-fitting planks and was divided into sections about 9½ feet by 24½ feet by 3 feet, having free volumes of about 700 cubic feet. The hydrocarbon content of air above the liquid level in the separator was determined by mass spectrometer analyses.

The radiotracer technique was used to measure the rate of air loss from this enclosed space. A glass tube containing 180 microcuries of krypton-85 was broken at one end of the air space to release the gas.* Radioactivity levels were measured with a thin-walled Geiger-Muller tube sensitive to the beta radiations from krypton-85, mounted centrally in the air space.

The counts were accumulated in a portable scaler. Scaler readings were recorded at one-minute intervals at the beginning of the test and less frequently when it became apparent that the loss rate was low. A plot of the counting rates above background is shown on Figure 1.

This chart shows the initial increase in counting rate as the tracer mixed with air in the enclosed space, followed by a period of uniform loss rate. From this chart, the mean residence time of the tracer gas and air in the enclosure was determined to be 53 minutes. Using the mean residence time, the system volume, and the hydrocarbon content analyses, the hydrocarbon loss rate can be calculated.

Another application was in measuring air replacement rate from an enclosure surrounding a hydrogen sulfide recovery unit. A continuous flow of air through the building was maintained by a steam eductor in a stack exhausting at the top of the building. It was not possible to reach the stack to measure the air rate while the plant was operating.

A stream of exhaust air from the stack was drawn through an existing sample line to a counting chamber to measure radioactivity level in the exhaust. Counting equipment was otherwise the same as described in the previous example.

Krypton-85 was introduced through a small hole at the base of the building. Air residence time in the structure was determined from the data plotted in Figure 2. Mean residence time for this test was determined to be 4.3 minutes. A second test of the same unit, using a different

* The authors are indebted to Dr. B. A. Fries for providing the capsule with a suitable quantity of tracer gas.

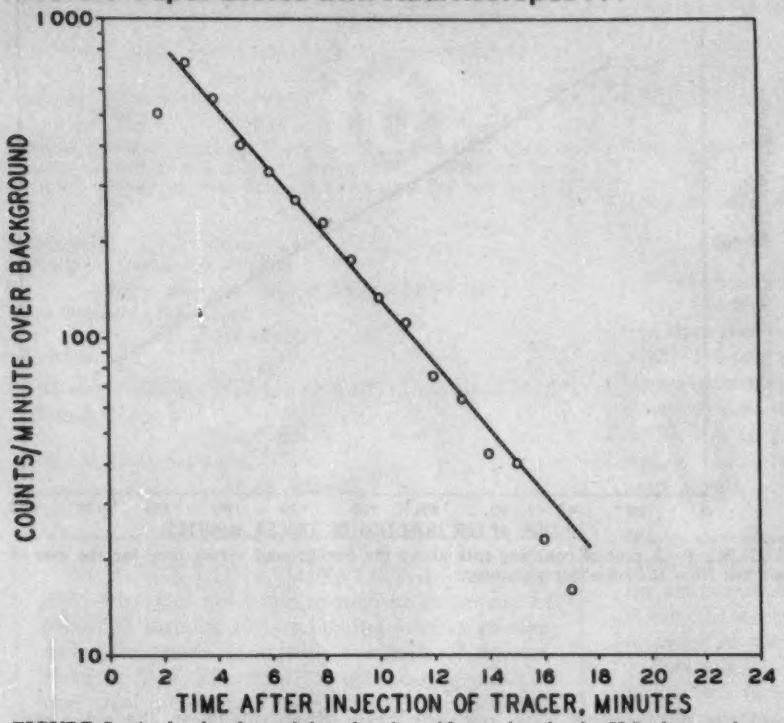

FIGURE 2—A plot for determining the air residence time in the H_2S plant enclosure. Mean residence time was 4.3 minutes.

point of introduction for the krypton-85, gave the same residence time, 4.3 minutes, indicating a good reproducibility for the method.

These items were considered in using radiotracers for measuring gas losses from enclosed space:

- Choice of radiotracer
- Possible loss of radiotracer by absorption, reaction, or condensation
- Rate and completeness of mixing radiotracer in the space to be studied.

Krypton-85 was used as the tracer because it is an inert gas, sufficiently long lived to be stocked for technical service and available at a reasonable cost.

It is only slightly soluble in water and hydrocarbons. Liquid samples obtained from the surface of an oil-water separator during a test contained no detectable amount of tracer.

A disadvantage of krypton-85 for the loss rate tests is that its radiations are essentially all beta, thus requiring the use of fragile beta counters instead of the more rugged gamma counters. Other volatile radiotracers might also be used e.g., methyl bromide or methyl iodide, although with greater chance of loss by absorption or reaction in some cases.

Mixing of the radiotracer in the gas spaces studied appeared to be complete and sufficiently rapid not to interfere with the method. In Figures 1 and 2, the first points show the approach to complete mixing in a short time compared with the residence time of the gas. A survey of the air space above the liquid in an oil-water separator during a test showed a uniform concentration of radiotracer after the initial mixing period. It has been observed in measuring air losses from oil-water separators that wind velocity and direction will affect losses from such enclosures, and such effects should be considered in obtaining average loss rate data.

The use of gaseous radioactive materials presents potential hazards of ingestion by breathing. For the tests described, the radiotracer was handled only by qualified technical personnel with precautions to avoid escape of the tracer gas. Krypton-85 is easily handled and transported in any heavy-walled container without shielding because it emits chiefly beta radiations. With the small quantities of tracer needed for the gas loss rate tests and the large dilution before escape from the enclosed spaces tested, no dangerous concentrations were encountered.

Tolerance concentrations for krypton-85 in air have not been officially established; but, by comparison with the figures for the similar inert gas, xenon-135, we have estimated a value of 3×10^{-6} microcuries/cc for continuous exposure. The concentration in the separator air space was only 10^{-8} microcuries/cc.

Use of electrical counting equipment where combustible gases may be present is another potential hazard in these tests. This problem was minimized by obtaining continual explosibility tests on the air around the test equipment and by use of a battery-powered, vapor-tight scaler and sealed electrical connections. With care, possible safety hazards may be controlled in the application of the radioactive method for measuring gas losses from enclosed spaces. ##

About the Authors

Hull

Brandel

Donald E. Hull, research associate for California Research Corp., received his Ph.D. degree in physical chemistry from the University of California in 1935. He then went to the University of Minnesota on a fellowship and a year later, joined the staff of the Chemistry department. In 1942, Atomic Energy Project work took him to the Physics department at Columbia University. Following that, Hull went to Carbide and Carbons Chemical Corp., then to Clinton Laboratory, and finally to California Research Corp., where he turned to industrial applications of radioactivity.

A. J. Brandel is a research engineer at California Research Corp., El Segundo, Calif., where he applies radiation methods to refinery testing and control, and studies air pollution control. Brandel received his B.S. degree in chemical engineering from the University of Wisconsin in 1945, and joined California Research a short time later. He has done technical service and research for the El Segundo refinery of Standard Oil Co. of California on petroleum treating, water treatment, and waste disposal.

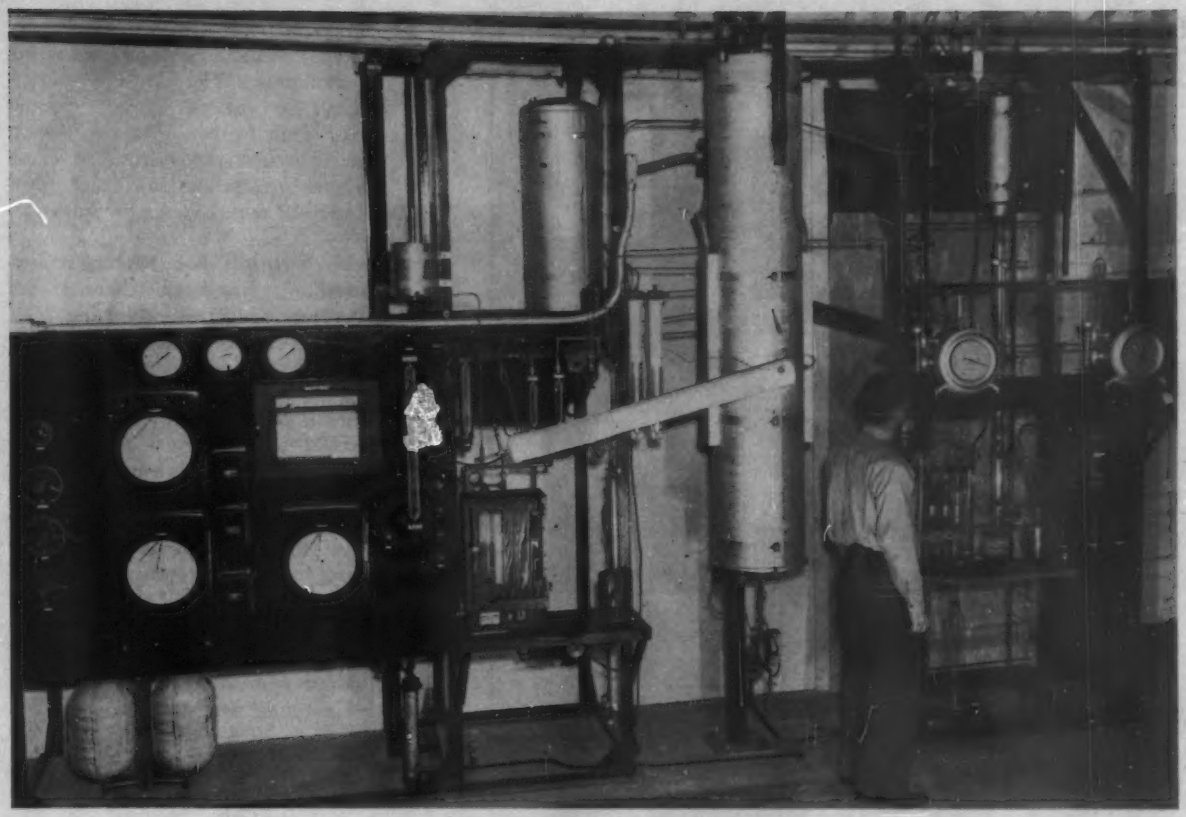

FIGURE 1—The pilot plant data compare closely with the results from commercial operation.

Better Yields After Nitrogen Removal

These data show the effects of nitrogen on yields from catalytic cracking. See how much improvement you can expect from nitrogen removal.

C. Kenneth Viland
Tidewater Oil Company
Associated, Calif.

GASOLINE PRODUCTION and quality can be expected to go up if unfavorable feed stock factors can be corrected or eliminated. This article summarizes some original data showing improvements in catalytic cracking yields which can be obtained by removing basic nitrogen from a heavy naphthenic California gas oil. The effect is substantiated by adding high boiling basic and non-basic nitrogen compounds to a highly paraffinic petroleum distillate from a foreign crude of low nitrogen content which normally produces exceptionally high yields of gasoline.

The unfavorable action of basic nitrogen compounds on cracking reactions is believed to be through neutralization of the active acid catalyst centers since activity is restored by regeneration. Sometimes nitrogen

Better Yields After Nitrogen Removal . . .

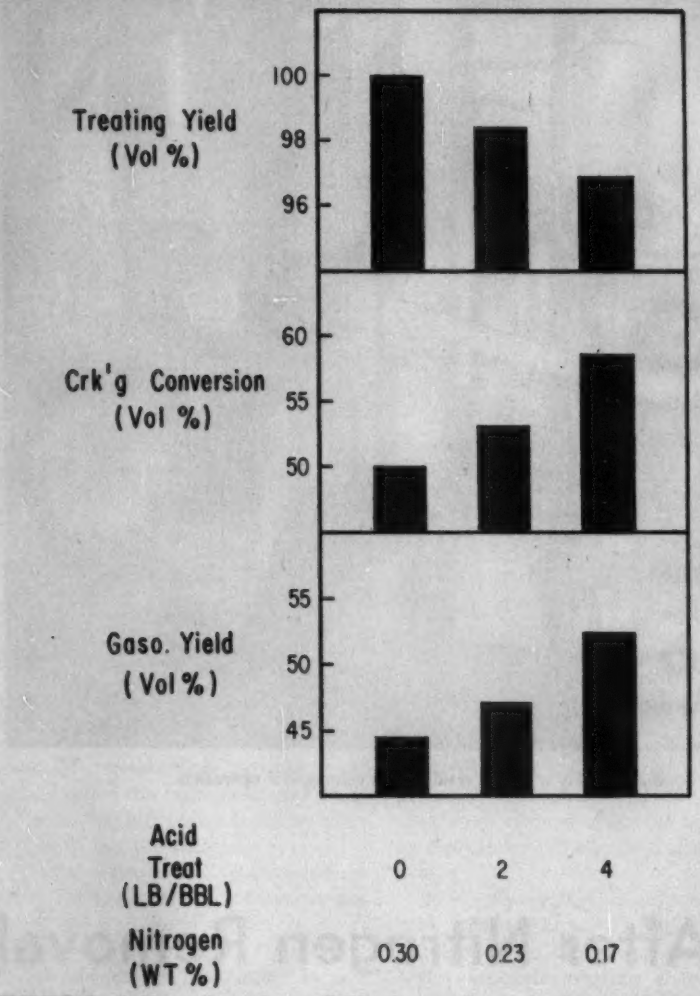

FIGURE 2—Acid treating a heavy California gas oil permits the subsequent catalytic cracking to give a higher gas oil conversion at a constant carbon make of 5 weight percent.

TABLE 1—Effect of Removing Basic Nitrogen with Spent Alkylation Acid

A. Treating Conditions			
Alkylation Acid Dosage—Lb./Barrel	0	2	4
Treating Temperature, °F	.....	200	240
Treated Oil Yield—Volume Percent of Charge	100.0	98.4	96.9
B. Properties of Oil (Source—California Crude)			
Gravity °API	21.1	21.2	21.6
Viscosity SSU @ 100 F	237	227	215
Sulfur—Weight Percent	0.88	0.89	0.86
Total Nitrogen—Weight Percent	0.30	0.23	0.17
Basic Nitrogen—Weight Percent	0.08	0.02	0.01
Ash—Weight Percent	0.004	0.003	0.001
Iron, Parts per Million	6.0	1.2	0.9
Vanadium, Parts per Million	0.10	0.08	0.08
Vacuum Distillation, Corr. to 760 mm Hg			
Initial Boiling Point, °F	479	425	420
10 Percent	621	627	627
50 Percent	762	770	763
90 Percent	917	915	910
C. Cracking Conditions*	0	2	4
Reactor Temperature, °F	984	985	984
Carbon on Regenerated Catalyst—Average Weight Percent	0.26	0.16	0.15
D. Catalytic Cracking Yields			
Carbon—Weight Percent	5.0	5.0	5.0
Conversion—Volume Percent Gas Oil Disappearance	49.8	53.0	58.4
Gas—C_3 and Lighter—Cu. Ft./Barrel Charge	385	371	383
Propane-Propylene—Volume Percent	6.1	7.4	9.9
Butanes-Butylenes—Volume Percent	8.8	9.9	13.7
Debutanized Gasoline—Volume Percent (390° F. @ 90 Percent Dist.)	35.6	37.3	38.8
Total Gasoline—C_4 and Heavier—Volume Percent	44.4	47.2	52.5
Gas Oil—Volume Percent	50.2	47.0	41.6
Research Octane—Debutanized Gasoline, Clear	93.7	94.5	94.3

* Using a mixture of 21 percent silica alumina microspheres and 79 percent sulfur resistant natural catalyst, the plant equilibrium catalyst having a U.O.P. weight activity of 21.

compounds are also associated with metallic contaminants such as nickel or vanadium. The latter when deposited on catalyst cause abnormal aging and further promote carbon and hydrogen yields so as to cause an even greater decrease in the production of useful liquid products.[1,2]

Acid Treating for Nitrogen Removal. It has been observed that petroleum distillates containing basic nitrogen compounds are among the worst offenders in producing high carbon deposits on cracking catalyst. Regeneration capacity for burning these deposits usually limits the capacity of a plant to convert unsalable distillates into high quality gasoline. Removal of these bases with strong or dilute sulfuric acid, formic acid, by hydrogenation, or even by pretreatment with a portion of the catalyst itself[4] will substantially improve cracking yields. To demonstrate this, a sample of heavy distillate from California crude was heated to 200-240 F., to aid in subsequent settling operations, and into it was dispersed spent alkylation acid containing 84.5 percent of H_2SO_4.

Immediately following the treatment the sludge was precipitated electrically so as to keep losses at a minimum. Acid dosage was 2 and 4 pounds per barrel, and the treated distillates were subsequently water washed. Data from these pilot plant tests are summarized in Table 1. Cracking yields are shown at a common coke make of 5 weight percent by plotting the data from several runs at varying levels of conversion. The four-pound-per-barrel treatment increased the production of gasoline from 44.4 percent by volume of the feed to 52.5 percent. This represents an increase of 18.1 percent in gasoline production while sludge loss was only 3.1 percent. The treated oil was found to be lower in iron and vanadium which would tend to improve the useful life of the cracking catalyst.

It will be noted that in addition to the improvement in yield of gasoline with respect to catalyst deposit, that the octane rating of the product was also increased. Simultaneously the gasoline volatility was favorably affected, the 50 percent distilled point of the gasoline being 261 F. from the

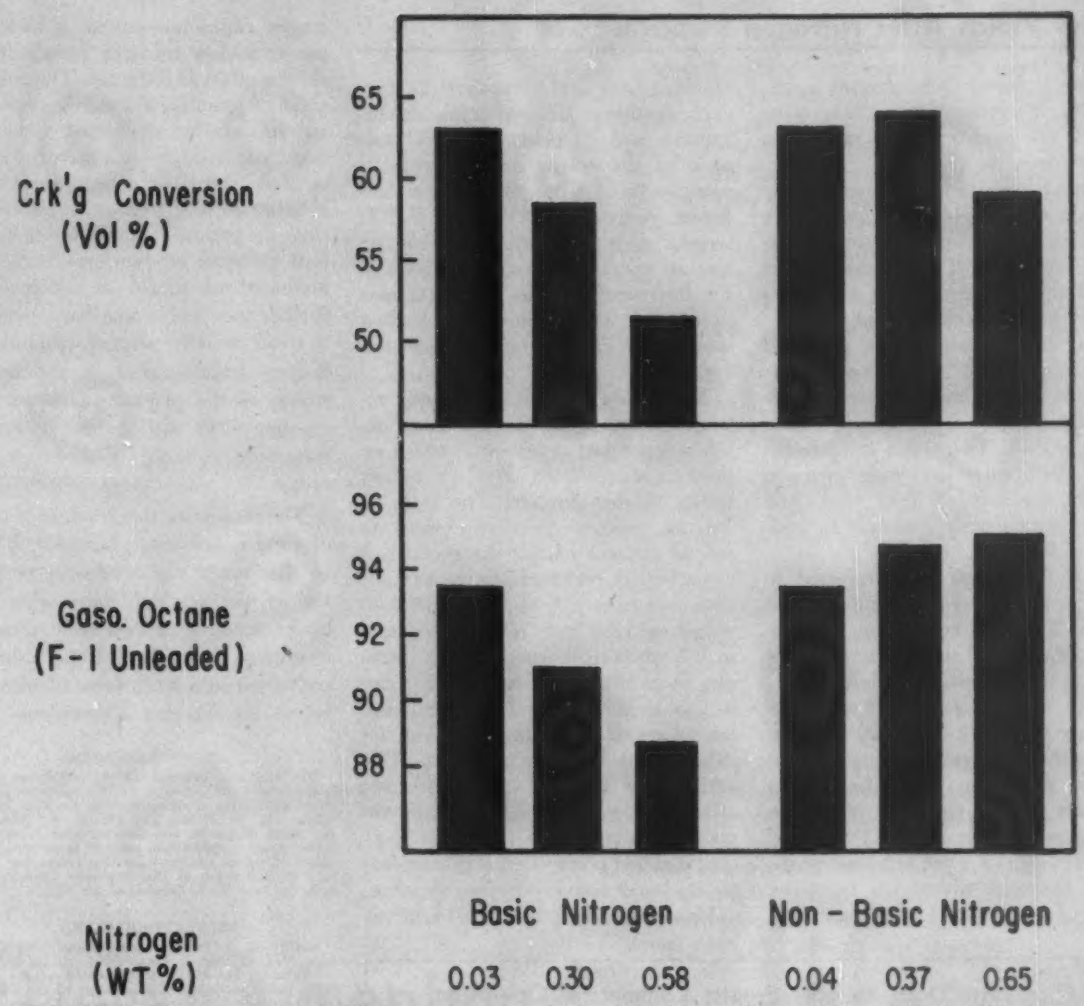

FIGURE 3—Nitrogen compounds added to a Sumatra gas oil affects the gas oil conversion and the gasoline octane.

untreated oil and the treated oils producing 255 F. and 245 F. 50 percent points respectively for the 2- and 4-pound acid treats at the conversion levels shown in the table.

Adding Nitrogen Compounds. A second study was made by adding typical basic and non-basic nitrogen compounds to a virgin paraffinic gas oil distilled from crude obtained from the Minas field in Sumatra. This stock is particularly low in nitrogen containing only 0.070 weight percent total nitrogen and 0.026 weight percent basic nitrogen. It is also low in sulfur content analyzing 0.09 weight percent.

For this investigation isoquinoline was chosen as the basic nitrogen compound, and indole was used as the non-basic nitrogen. Both boil in the catalytic cracking feed stock range

TABLE 2
Effect of Adding Basic and Non-Basic Nitrogen

	Virgin Minas Gas Oil	Plus Isoquinoline (Basic Nitrogen)		Plus Indole (Non-Basic Nitrogen)	
A. Properties of Oil					
Basic Nitrogen, Weight Percent	0.03	0.30	0.58	0.02	0.02
Non-basic Nitrogen, Weight Percent	0.04	0.08	0.04	0.37	0.65
Gravity, °API	31.3	30.4	29.7	30.5	29.7
Viscosity-SSU @ 100° F	44.2	43.5	42.3	43.6	42.7
Sulfur, Weight Percent	0.09	0.09	0.09	0.10	0.10
Ash, Weight Percent	0.01	.....	.....	.....	.....
Wax, Weight Percent	47.0	.....	.....	.....	.....
Vacuum Distillation, Corr. to 760 mm Hg					
Initial Boiling Point, °F	514	446	488	475	494
10 Percent	698	696	624	687	636
50 Percent	836	836	744	833	746
90 Percent	1010	1011	Cracked	995	Cracked
B. Cracking Conditions					
Reactor Temperature, °F	985	985	985	985	985
Carbon on Regenerated Catalyst—Average Weight Percent	0.10	0.09	0.10	0.12	0.14
C. Catalytic Cracking Yields					
Carbon, Weight Percent	5.0	5.0	5.0	5.0	5.0
Conversion, Volume Percent Gas Oil Disappearance	63.2	58.5	51.7	64.2	59.2
Gas C_2 and Lighter—Cu. Ft./Barrel Charge	277	435	430	352	318
Propane-Propylene, Volume Percent	13.9	9.9	7.2	15.5	11.8
Butanes-Butylenes, Volume Percent	16.8	14.3	10.0	18.8	14.5
Debutanized Gasoline, Volume Percent 390° F. @ 90 Percent Distilled	40.6	38.9	35.5	39.6	38.8
Total Gasoline—C_4 and Heavier, Volume Percent	57.4	53.2	45.5	58.4	53.3
Gas Oil, Volume Percent	36.8	41.5	48.3	35.8	40.8
Research Octane—Debutanized Gasoline, Clear	93.5	90.9	88.8	94.8	95.1
—with 3.0 ml TEL/Gallon	98.3	97.7	96.0	99.6	99.7
Volatility of Gasoline—50 Percent Distilled—°F	202	234	248	193	201

and are believed to be present in petroleum. Furthermore these compounds are readily soluble in the gas oil distillate.

Catalytic cracking tests were made on four nitrogen-blended feed stocks in addition to the low-nitrogen reference oil. Table 2 shows the properties of the five feed stocks as well as the results of the experiment.

Two charge stocks were prepared containing basic nitrogen in the amounts of 0.30 and 0.58 weight percent by adding isoquinoline to the virgin gas oil. Two other comparable stocks containing non-basic nitrogen in the amounts of 0.37 and 0.65 weight percent were prepared by adding indole.

Each feed stock was subjected to 4 or 5 laboratory cracking tests at various levels of conversion and the yield data plotted so that comparisons could be made using any desired parameter. Since catalyst regeneration capacity is usually the limiting factor in commercial operations, the comparison shown is on the basis of a common 5 weight percent of carbon burned as catalyst deposit.

The catalyst for the test was equilibrium material withdrawn from the Avon commercial fluid catalytic cracking unit and comprised 21 percent synthetic silica-alumina microspheres and 79 percent natural catalyst of the sulfur resistant type as manufactured from the mineral halloysite. Activity was 21 on the U.O.P. weight scale. In order to eliminate any accumulative poisoning effects of the feed stocks on the catalyst a new sample of the equilibrium catalyst was used in each of the laboratory test runs.

These data show that the basic nitrogen compound, isoquinoline, exhibits a marked detrimental effect on product distribution and on octane rating of the gasoline. The ratio of volume percent gasoline yield to weight percent of the charge burned as carbon in regenerating the catalyst decreases from 11.5 to 10.6 in the 0.30 weight percent basic nitrogen test and to 9.1 when 0.58 percent basic nitrogen is present. It was found there is a sharp drop in both the clear and leaded research octane ratings of the debutanized gasoline product. The addition of basic nitrogen adversely affects the volatility of the catalytic gasoline as measured by the 50 percent distilled point. This is in part due to the lower conversion into gasoline.

However, when the non-basic nitrogen compound indole is added to the same low nitrogen paraffinic gas oil the effect is different. The relative yield of gasoline to catalyst deposit is substantially unaffected when the non-basic nitrogen content is increased from 0.04 weight percent to a figure of 0.37 percent. At the same time the octane rating of the debutanized gasoline product was noticeably increased as shown in Table 2. A further increase in non-basic nitrogen to 0.65 weight percent produced a further improvement in the octane rating of the product; however, the gasoline yield with respect to carbon formation suffered a moderate decrease.

The reason for this reversal of trend of yield is unknown; however, it may be that under the conditions pertaining in the reaction zone when the larger amount of non-basic nitrogen is present, that part of the indole is converted to a basic form of nitrogen before the reaction is complete.

ACKNOWLEDGMENT

The author is grateful for the permission of the management of Tidewater Oil Company to publish these findings, and recognition is given to W. M. Miller, R. R. Wilde, and Dr. F. K. Sabott of the Avon Research and Development department from whose unpublished reports these data were taken. Original presentation was before the Division of Petroleum of the American Chemical Society in New York, September 11, 1957.

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Pilot Plant Data Reliably Predict Commercial Operation

THE DATA here reported have been obtained from carefully controlled tests in a small catalytic pilot plant.[5] This laboratory unit is capable of reproducing the important operating variables of commercial fluid catalytic cracking. A comparison of the small pilot plant and large scale operation is of interest. The same feed stock and the same catalyst was used in both operations—a 24-hour composite of the 22.1° API heavy gas oil from mixed California crudes being taken for the pilot plant test, and also a composite sample of the 32 U.O.P. weight activity synthetic silica alumina catalyst. This catalyst had been contaminated from the feed stocks used commercially as follows: Fe-1950 p.p.m.; Ni-325 p.p.m.; V-85 p.p.m.; and Cu-36 p.p.m. The feed stock in these tests contained 0.26 weight percent of nitrogen. Operating conditions for the laboratory and commercial cracking units were as follows:

Operating Conditions for Cracking

	Laboratory	Commercial
Reactor Temperature °F.	955	954
Reactor Pressure	3.3 inches water	17.0 psig
Catalyst—Oil Ratio—Wt.	8.2	8.1
Stripping Steam Lb./1000 Lb. Catalyst	4.2	5.1
Other Steam Lb./1000 Lb. Catalyst	2.4	1.3
Carbon on Regenerated Catalyst—Wt.%	0.29	0.26

The yields obtained under these conditions from the same feed and catalyst are as follows:

Yields in Cracking

	Laboratory	Commercial
Conversion—% Gas Oil Disappearance	44.6	44.6
Carbon—Wt.%	4.7	4.6
Hydrogen in Coke—Wt.%	5.6	8.5
Dry Gas—Cu.Ft./Bbl. charged	307	313
Propane-Propylene—Vol.%	5.9	6.0
Butanes-Butylenes	8.0	8.0
Debutanized Gasoline-390° F. @ 90%	32.2	32.2
Total Liquids—C_4 and heavier	95.6	95.6

These comparative data are reported to indicate that the laboratory equipment used provides a reliable means of predicting yields from other stocks.

About the Author

C. Kenneth Viland is general supervisor of the research and development department, Western division, Tidewater Oil Company. He received his B.S. degree in petroleum engineering from Colorado School of Mines, Golden, Colorado, in 1929, then joined Associated Oil Co., which later became a part of Tidewater. Viland assumed his present position in 1946.

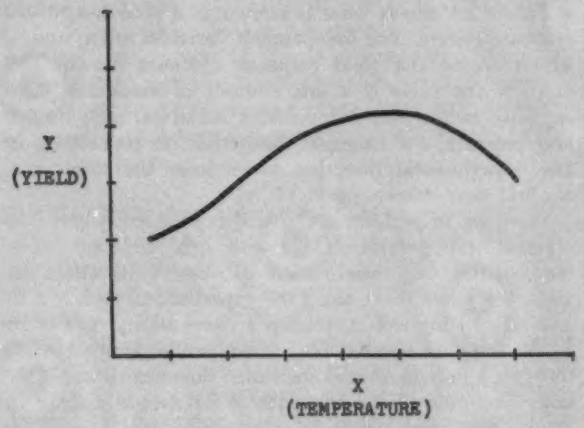


FIGURE 1—If only one independent variable is changed at a time, we may never discover the interrelation of variables.

Plan Before You Start Experimenting

Your data will be more valuable if you plan your runs beforehand. Here is how to tell when factors operate jointly to influence a system.

Hugh F. Smith
E. I. duPont de Nemours & Company
Orange, Texas

ALL TOO OFTEN, experimenters ask for statistical assistance only after their experiments have failed to produce the answers anticipated. Their problem arises not from lack of data (they have reams of it) but from an inability to interpret the data at hand.

In some cases, the data were obtained in such a random manner that few or no valid conclusions can be drawn. In others, only limited conclusions are possible because the experiment was not designed with a statistical analysis in mind. Those few experiments that can give valid conclusions are seldom as efficient as they might have been had a statistically sound design been used.

In a nutshell, too many experimenters ignore the obvious injunction that the time to design an experiment is before the experiment has begun.

The chief deterrent to wider use of statistical designs in the past has been the extremely large number of experimental runs required to investigate several experimental variables at various levels. For example, a standard factorial experiment involving three variables, each at three levels or conditions, results in 27 different experimental combinations of the three variables. An increase in either the number of variables or the number of levels rapidly runs up the experimental combinations to impractical proportions for most industrial production processes.

There is a way around this stumbling block. This way is a relatively new development, but only in the sense that it is a novel application of old but well known mathematical principles to the design of experiments.

A second objection to the statistical designs advanced by some experimenters is the statistician's "unreasonable" insistence on randomization in setting up the order of experimental runs. As regards this objection, the statistician can only offer his sympathy. The principle of randomization is absolutely essential to the design of valid experiments. The fact that randomization may make the experiment more troublesome to administer should be irrelevant to the experimenter who desires usable information.

Optimum conditions are the ultimate goal of any industrial experiment. We experiment to locate those independent operating settings for a process which will either maximize dependent responses such as yield, conversion, and production rate, or conversely, minimize responses such as cost and impurity levels.

The basic philosophy behind the new approach to industrial experimentation is the determination of those optimum conditions and the method is largely due to the contributions of G. E. P. Box. Hence, the method is now generally known as the "Box Method of Experimentation."

The Box method determines the surface contours of a dependent response to the independent experimental conditions imposed on a process. Its outstanding attribute is that a maximum of information can be extracted from a minimum of experimentation. In other words we get a more profitable return from our experimental dollar, an important consideration both to industry and to academic research.

Any experiment, Box or otherwise, entails setting up

a pattern of independent variables at which we measure some dependent variable. An independent variable is one which we have the power to control at any desired level irrespective of the setting of any other variable. A dependent variable is one which we observe as a response to the particular settings of the independent variables.

Considerable confusion in interpreting data can be caused by failure of the experimenter to recognize the difference between independent and dependent variables. It is not at all uncommon to see experiments, for example, wherein yield is determined as a function of conversion level. Here, conversion is used as an independent variable although obviously it is really a dependent response to one or more truly independent variables. Such misuse of experimental variables can be very misleading since the amount of yield at a given conversion level may depend largely on the experimental path by which the particular conversion level was attained.

The simplest type of experiment will illustrate the effect of one independent variable on a dependent variable so that we may see what is meant by a response. Figure 1 shows results of such an experiment as a response curve or line.

Yield is shown responding to the effect of various levels of temperature. This manner of presentation is familiar to all of you, wherein the response contour is a line, not a surface, since there is only one independent dimension involved.

As soon as a second independent variable or dimension is introduced, our response curve then becomes a surface contour. A curved surface is difficult to picture on a flat sheet of paper. Figure 2 shows some typical response surfaces as contour lines.

The axes shown are those of the two independent variables of the experiment. A third axis, that of the dependent response, may be visualized as perpendicular to the other two axes. The contour lines shown represent levels of equal response.

Figure 2A shows what is known as a stationary ridge response system. The independent variables are x_1 and x_2 which create the yield response contours shown. The crest of the ridge is a line contour of maximum yield response to the two independent variables, temperature and pressure, for example. Note that on proceeding in any experimental direction away from the ridge line, we find ever decreasing yields.

Were we to perform a classical experiment where one variable, say pressure (x_2) were held constant while temperature (x_1) was varied to observe its effect on yield, we would move along the experimental path *A E B*, and on plotting would develop a curve similar to Figure 1. At some temperature, yield would appear to go through a maximum and then turn downwards on either side. The point *E* on the path *A E B* would appear to be the maximum yield.

The next step in the classical experimentation procedure would be to hold temperature (x_1) at the apparent optimum value and proceed to vary the pressure (x_2) to observe its effect on yield. This would correspond to movement along the experimental path *C E D*. Again, at some pressure level a maximum yield response (point *E*) would be observed which, within the limits of experimental and measurement error, would be nearly identical to the maximum value noted when temperature alone was varied.

Hence, the classical experimenter would conclude (and rightly so) that operation of the process at the indicated values of temperature and pressure would result in optimum yield.

Only part of the story is told by this conclusion. True, the experimenter has succeeded in placing the process on the ridge crest, but he is totally unaware of the existence of the ridge system. If the question of spatial position has occurred to him at all, he would probably visualize the process to be on a mountain peak of yield response.

Since he has no knowledge of the ridge system, the experimenter does not realize that there are an enormous number of combinations of temperature and pressure which will also give the same maximum yield response

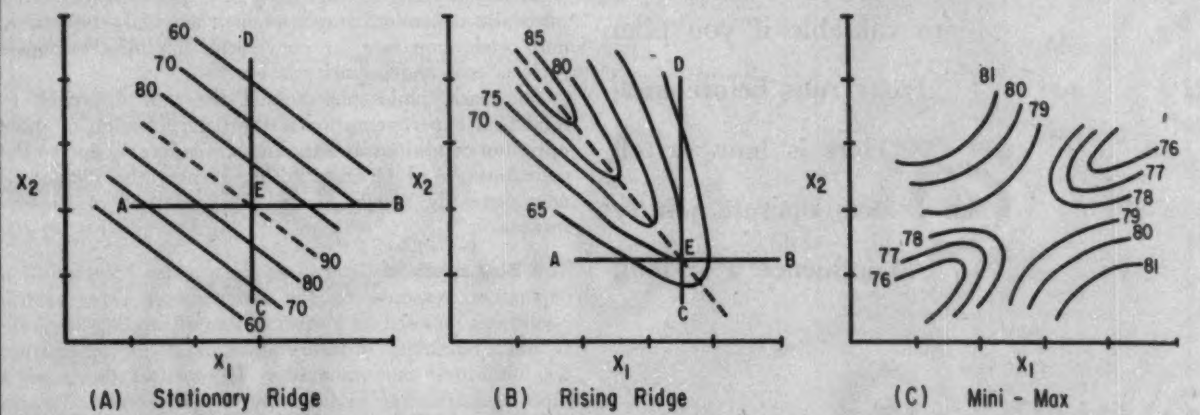


FIGURE 2—As soon as a second independent variable is introduced, our response curve becomes a surface contour.

he has observed. The particular values of temperature and pressure which he has discovered are not a unique optimum, and, unless he has been extremely fortunate, are probably not the most desirable operating conditions from the standpoint of other important considerations such as production rate, cost, and quality of the finished product.

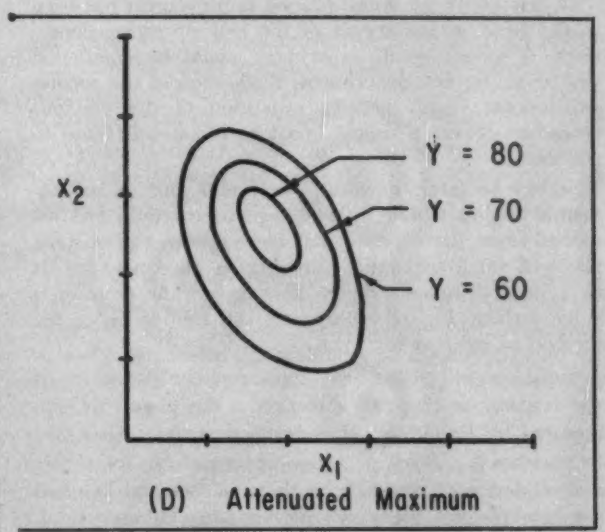
Another type of response surface known as a rising ridge system is shown as Figure 2B. In this type, the ridge line is not parallel to the plane of the two experimental variables, but inclines at some angle, however slight.

As in the first example, contour lines at equal yield response are shown. We are familiar with contour maps in which lines of equal altitude are similarly drawn. The yield in this case corresponds to the altitude. By proceeding up the ridge line, we would observe ever increasing or higher yields and would be headed in the right direction for eventual attainment of optimum yield. Note carefully, however, that simultaneous changes in both independent variables, x_1 and x_2, are essential to maintain the process on the ridge.

Examining such a system by the classical approach, we would change one variable at a time. First, we move along the experimental path *A E B* to find the maximum yield for values of x_1. Then, we hold x_1, constant and proceed to study the effect on yield by varying x_2 along the path *C E D*. As before, if x_1 represents temperature and x_2 represents pressure, we note an optimum yield for both variables. Considering measurement error, the two yield values obtained at constant pressure and at constant temperature are equivalent.

From this experimental information, our classical experimenter reasons that operation of the process at the indicated values of temperature and pressure will result in an optimum yield.

He is dead wrong. Totally unaware of the true nature of the yield response surface, he has managed to establish the process on a ridge which, like a blindfolded man, he concludes to be a mountain peak. From his presumed peak of yield, he has surveyed along a North-South path and along an East-West path, and has found that yield falls off in all directions. However, it has not occurred to him to survey the yield picture along a North-West experimental path. Although higher yields lie up the slope of the ridge in this direction, his system of experimentation has failed to detect this vitally important fact.



(D) Attenuated Maximum

A third type of response surface, called a maximum, is shown in Figure 2D. This surface resembles that of a mound rising from a plane. Here, we have lines of equal yield contours shown girdling the mound peak. This system obviously has a unique optimum which can only be attained by one specific combination of the independent variables, x_1 and x_2. Any other combination of operating conditions would move the process off the peak response and result in lower than optimum yields.

A response surface of this nature could be successfully handled by classical experimentation procedure, but only after many "cut-and-try" experiments, especially if the yield contours were not nearly circular.

A fourth type of response surface, called a mini-max, is shown in Figure 2C. This surface can best be visualized as a saddle-shaped surface. From a central point in the seat of the saddle, the surface curves upward in two opposite directions, and curves downward in two opposite directions, 90° apart.

Classical experimentation on such a response system might lead to discovery of higher yields, but the true nature of the surface would escape detection. The experimenter might discover one of the upward sweeping curves of the surface, but he would be totally unaware that another existed where the same yield could be obtained at possibly more advantageous operating conditions.

Thus far in our discussion, we have considered relatively simple experiments dealing with one or two independent variables or factors. The difficulties faced by the classical experimenter when dealing with three or more experimental factors become even more acute.

Obviously, for four or more independent factors, there is no way to depict, or for our minds to obtain, a mental picture of the nature of the response surface. For three experimental factors, however, the response can be visualized as a contour surface.

Figure 3 shows some of the possible three factor response contour surfaces. To avoid too much detail, a description of each of these types will be omitted. As an example, it might be noted that the three factor response analogous to the two factor maximum response previously discussed is designated as ellipsoid on Figure 3A. Each point on the surface of the ellipsoid represents an equal level of the response to the three experimental factors designated by the axes x_1, x_2, and x_3 which might

TABLE 1—Number of Terms Required to Establish an Equation

k = No. of Factors	d = Degree of Fitted Equation			
	1(Plane)	2(Quadratic)	3(Cubic)	4(Quartic)
2	3	6	10	15
3	4	10	20	35
4	5	15	35	70
5	6	21	56	126

Example: Ten terms required for complete 2nd degree equation in 3 factors.
$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{11}x_1^2 + b_{22}x_2^2 + b_{33}x_3^2 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3$

be temperature, pressure, and catalyst concentration.

Inside the shell of the ellipsoid should be visualized a series of smaller and smaller concentric ellipsoids, the surface of each representing an ever increasing response level. In other words, these surface contours approach and enclose the central maximum point like the skins of an onion around its center.

A better system of experimentation is obviously needed if we are to avoid the snares and delusions which await the unwary experimenter. The Box Method is by far a sounder approach to experimentation.

In essence, the Box Method explores a process by mathematically fitting a sufficiently elastic surface to the response values observed at a carefully selected set of operating conditions. Unless special knowledge of the process dictates otherwise, the empirical mathematical model used is the generalized polynomial equation.

The complexity of this generalized equation depends upon the number of independent variables in the experiment and upon the degree of the equation required to fit the response surface. In Table 1 is shown the required number of terms or coefficients to be determined to fit equations of varying degree in from two to five independent experimental factors.

The number of experiments to be performed must be at least as great as the number of coefficients in the generalized equation of the mathematical model. As the table indicates, the minimum number of experiments increases rapidly with both the number of experimental factors and the degree of the equation to be fitted. However, it is important to note that equations of high degree are required only if trying to fit the response surface of an entire experimental region. This step is unnecessary and very undesirable because of the excessive experimental program involved.

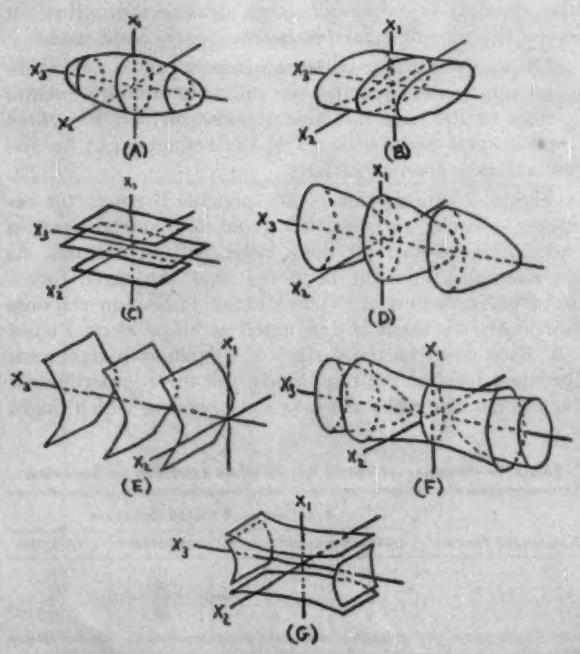


FIGURE 3—Here are just a few of the response surfaces possible when three factors are involved.

It is usually possible to examine the response surface in a limited experimental region by means of a fairly small experiment. We can begin by fitting simple linear or first degree equations. Then, by using the results of this first experimental pattern to guide the setting up of the next, we can proceed towards process improvement by means of a series of sequential but relatively small experiments.

The Box Method can be generalized for any number of factors but for simplicity in explanation, we will consider an experiment in just two independent factors.

The linear equation in two factors represents the response as a plane surface. As indicated in Table 1, an appreciable saving in the number of experiments is realized provided a linear fit is adequate. The form of the linear model is as follows:

$$y = b_o + b_1x_1 + b_2x_2 \qquad (1)$$

where y is the response, and b_o, b_1, and b_2 are the coefficients to be determined.

The data from the experiment are then used to determine the unknown coefficients of Equation (1) by the statistical procedure known as "least squares," the details of which will be omitted from this paper. This procedure is a completely algebraic manipulation guaranteeing that the sum of the squared differences between predicted y and observed y is a minimum for the value of b_o, b_1, b_2 so determined.

Assuming that the flat plane surface represented by Equation (1) provides a reasonably good fit to the data, its direction of slope can be determined. Then, an initial process improvement can be realized by proceeding up (or down) the slope in the direction of steepest ascent (or descent). The direction to proceed, of course, depends on whether the response variable is one which we desire to maximize or minimize.

In any event, an initial process improvement has been made. Now, in the region of the new operating conditions, a second small experiment could be conducted similar to the first experiment. Evaluation of this second experiment would then be repetition of the previous procedure where a simple linear equation was fitted to the data.

Sooner or later, however, we would find an experimental region where little change occurred in the response when the experimental factors were varied. Our series of small sequential experiments have now led us to a near stationary region perhaps on the crest of a ridge surface. Figure 4 illustrates the application of the method of steepest ascent.

Since on and about the ridge crest the curvature of the response is changing direction, a flat planar fit represented by Equation (1) is inadequate. It is necessary to perform a pattern of experiments suitable for fitting a second degree equation to the now definitely curved response surface. Such an equation is as follows:

$$y = b_o + b_1x_1 + b_2x_2 + b_{11}x^2_1 + b_{22}x^2_2 + b_{12}x_1x_2 \qquad (2)$$

Note that the first three terms are identical to Equation (1), and that three additional terms have been added, each with unknown coefficients, b_{11}, b_{22}, and b_{12} to be determined. Our experimental pattern must now be expanded in order to fit the data to the enlarged equation.

After performing the expanded experiment and fitting the response data to the quadratic equation, the subsequent analyses will usually indicate the presence of surface features requiring further study. The existence of a local maximum, a mini-max, or some form of the stationary or rising ridge might be suggested. For confirmation, further exploratory points could be added to the experiment and the surface refitted to include both old and new response data.

Under unusual conditions, it might appear that a second degree equation inadequately described the response surface. Resort to a third degree equation is not recommended for several reasons:

- The usefulness of so involved an equation is extremely limited.
- Plotting the contours of a cubic model would entail much labor.
- There are no easily understandable forms for cubic equations.

Therefore, should a second degree model indicate a significant lack of fit to the response data, it would be a far wiser course to re-appraise the nature of the experimental variables with a view to re-scaling them. Perhaps reciprocals, or logarithmic or trigonometric functions should be used rather than the arithmetic form for the experimental variables or for the response variable. The degree of control of other variables not entering the experiment should also be reviewed to assure their constancy. Only in exceptional cases should a quadratic equation prove totally inadequate.

The technique of fitting and analysis of the second degree equation after attainment of a near stationary region is a powerful tool by which we can obtain a clear picture of the response system under study. The fitting procedure by "least squares" is described in several texts. The analytical method after fitting consists essentially of reducing the equations to a standard form.

We are familiar with the standard or "canonical" forms of equations for a circle ($x^2 + y^2 = r^2$), or an ellipse $\left(\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1\right)$. Similarly, canonical forms exist for quadratic surfaces.

Let us take for example, the fitted second degree Equation (2) previously described. The coefficient b_o represents a constant of the equation. The coefficients b_1 and b_2 are called linear effects, coefficients b_{11} and b_{22} the quadratic effects, and coefficient b_{12} the interaction effect.

Purely by inspection of these coefficients of Equation (2), we would probably be at a loss if asked to describe the surface of y represented thereby. Then too, where more than two independent variables are involved, the equation becomes an even more hopeless task to elucidate.

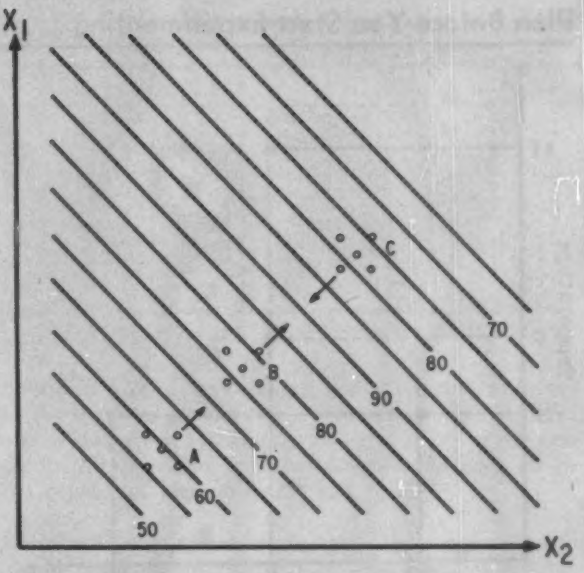


FIGURE 4—After the first set of runs are made, it is possible to determine the direction for the next set.

The canonical analysis of the equation aids us by simply restating the complex equation in a more comprehensible form. There are only two basic types of response surface which this second degree equation can represent. Figure 5 shows these two basic types as Figure 5A and Figure 5B. Also shown are the stationary ridge (Figure 5C) and the rising ridge (Figure 5D). These last two surfaces can be regarded as special forms of the two basic surface types.

If we use the center of the system as origin and trans-

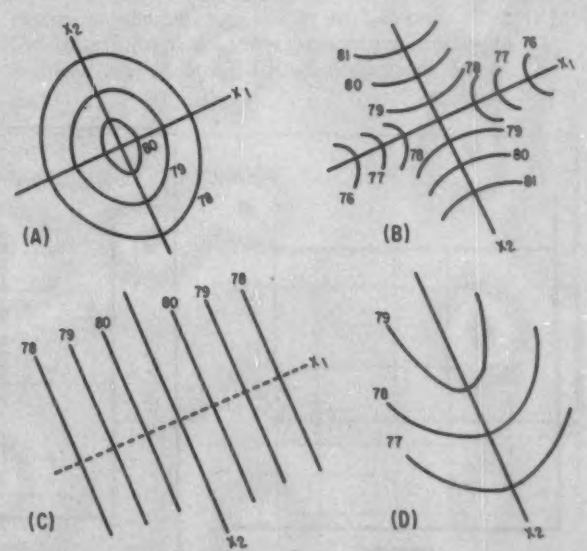


FIGURE 5—The axes (x_1 and x_2) may be rotated so that a standard equation is obtained having the following form: $Y - Y_o = B_{11}X_1^2 - B_{22}X_2^2$.

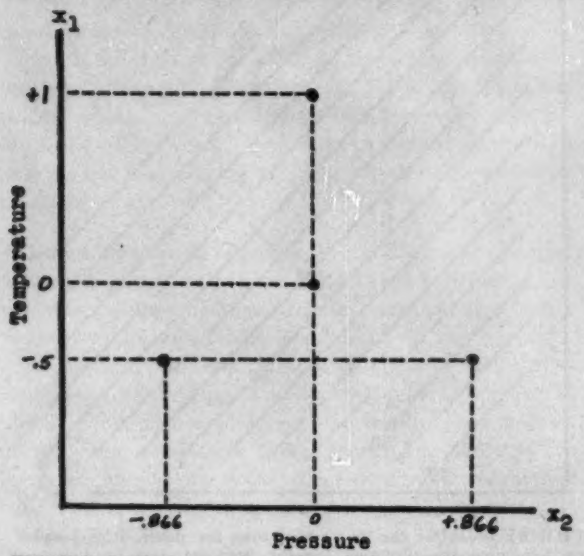


FIGURE 6—Each experimental variable, should be scaled to give an equivalent change in the dependent variable.

late and rotate the axes x_1 and x_2 to X_1 and X_2 as axes of a new coordinate system, the complex second degree equation will then be reduced to the form:

$$Y - Y_s = B_{11}X_1^2 + B_{22}X_2^2 \qquad (3)$$

where Y is the response variable.

Y_s is the predicted response of the center or stationary point of the system.

B_{11} and B_{22} are coefficients of the canonical equation. Thus, by transformation of the original axes, we have reduced the second degree Equation (2) to Equation (3) with only the two quadratic effects B_{11} and B_{22}.

The type of surface represented by our original fitted second degree equation is now easier to discover. For example:

(a) If B_{11} and B_{22} are of like sign, we have a unique maximum response contour such as Figure 5A. In this illustration, both B_{11} and B_{22} are negative in sign. Had both been positive, the surface would have been a depression, rather than a mound, and the center or stationary point would be a minimum.

(b) If B_{11} and B_{22} are of opposite sign, we have a saddle shaped or mini-max surface such as Figure 5B.

(c) In either (a) and (b) above, if one of the coefficients is small compared to the other, the surface is attenuated or elongated along the axis of the smaller coefficient. In Figure 5A, for example, the B_{22} coefficient is slightly smaller than B_{11}.

(d) If one of the coefficients is zero or nearly so, we would have a stationary ridge system such as Figure 5C. In this illustration, B_{22} coefficient is zero, meaning infinite elongation along the X_2 axis.

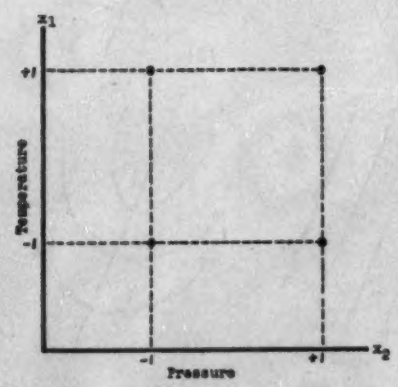
(e) If one of the coefficients is zero and if the center of the system were at infinity, we would have the rising ridge surface such as Figure 5D. In this illustration, B_{22} coefficient is zero.

For purposes of simplicity, the canonical analysis for for only two independent experimental factors has been discussed. However, the analytical technique is not limited, but can be generalized for any number of experimental factors.

The design of an experiment to utilize the Box technique depends on (1) the number of independent factors involved, (2) on the degree of the equation that is to be fitted, and (3) on whether an estimate of the experimental error is desired from the experiment itself.

To facilitate calculations, the actual levels of the independent variables are first coded to a new set of variables called the design variables. The coding is selected so that the coordinates of the design center are zero in all experimental dimensions. In so far as the designer's "feel" for the process will permit, he should attempt to code the independent variables so that a change of one unit of the code in each variable will have approximately the same degree of effect on the response variable. This, obviously, is not always possible, but is a highly desirable endeavor.

G. E. P. Box and his co-workers have worked up a



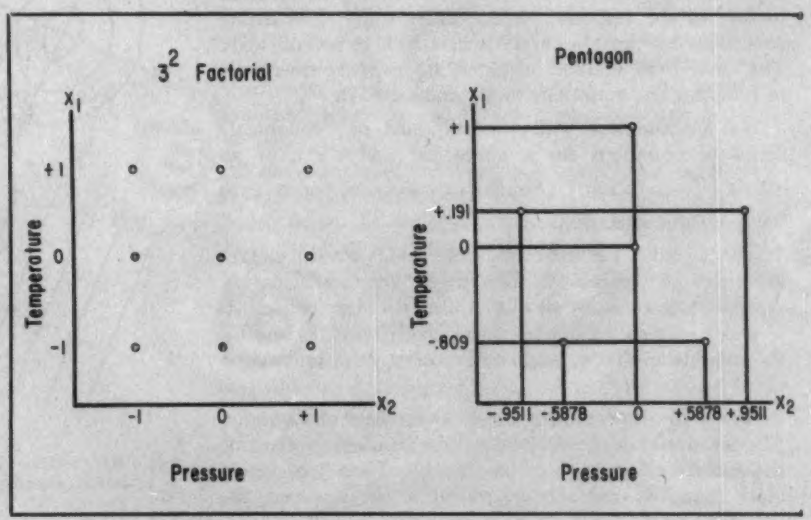


FIGURE 7—An alternate design for the two factor linear model could be this 2^2 factorial set of runs.

variety of experimental designs. As research in this field continues, there will undoubtedly be further developments. The following is a brief description of current satisfactory designs.

For two experimental factors, the simplest type would be as shown in Figure 6. This design is suitable for fitting a first degree equation in two factors: $y = b_o + b_1x_1 + b_2x_2$. Three of the experimental runs form an equilateral triangle in the coded dimensions with a fourth run located one-third of the distance from the base to the apex. Replication (re-running) of the fourth or center point is desirable to obtain an estimate of the experimental error, and to test the data for lack of fit to the linear model.

An alternate design for this two factor linear model would be a standard 2^2 factorial shown in Figure 7. However, an advantage possessed by the triangle design is that it is a "rotatable" design in any orientation.

By the term "rotatable" we mean that the design is capable of predicting a response value with equal precision at equal distances from the design center. The 2^2 factorial does not possess this feature, and hence suffers some "astigmatism" in its prediction precision, the amount depending on the direction of the experimental region from the design center.

The preliminary experiments may indicate that the linear model fits the response data unsatisfactorily, it would then be necessary to perform two factor experiments capable of fitting a second degree equation:

$$y = b_o + b_1x_1 + b_2x_2 + b_{11}x_1^2 + b_{22}x_2^2 + b_{12}x_1x_2$$

There are a variety of designs for this case as shown in Figure 8.

With the exception of the 3^2 factorial experiment which is highly "astigmatic," all the other designs are "rotatable". It should be noted that in two experimental dimensions an infinite number of designs are available since all regular polygons of five or more sides qualify provided at least one point is added at the center.

It should also be noted that the minimum design, a regular pentagon, has one important disadvantage. The design cannot allow assessment of the data for lack of fit to the quadratic model. There are only six experimental points and there are exactly six coefficients to be estimated. Use of the pentagon design amounts to force-fitting the response data to a quadratic curved surface, and is analogous to fitting a straight line through two points. All other designs from the regular hexagon on up are capable of assessment for lack of fit.

TABLE 2—Typical Four Factor Design
2^4 (Central Orthogonal Composite) = 25 Runs

Y	x_1	x_2	x_3	x_4	Y	x_1	x_2	x_3	x_4
Y_1	−1	−1	−1	1	Y_{14}	1	1	−1	−1
Y_2	1	−1	−1	1	Y_{15}	1	1	1	−1
Y_3	1	−1	1	1	Y_{16}	−1	1	1	−1
Y_4	−1	−1	1	1	Y_{17}	0	0	0	0
Y_5	−1	1	−1	1	Y_{18}	1.414	0	0	0
Y_6	1	1	−1	1	Y_{19}	−1.414	0	0	0
Y_7	1	1	1	1	Y_{20}	0	1.414	0	0
Y_8	−1	1	1	1	Y_{21}	0	−1.414	0	0
Y_9	−1	−1	−1	−1	Y_{22}	0	0	1.414	0
Y_{10}	1	−1	−1	−1	Y_{23}	0	0	−1.414	0
Y_{11}	1	−1	1	−1	Y_{24}	0	0	0	1.414
Y_{12}	−1	−1	1	−1	Y_{25}	0	0	0	−1.414
Y_{13}	−1	1	−1	−1					

Allows estimate of linear and full quadratic effects of four factors and leaves 10 d.f. for error.

For three experimental factors, the simplest design would be as shown in Figure 9. This design is suitable for fitting a first degree equation as follows: $y = b_o + b_1x_1 + b_2x_2 + b_3x_3$. The total of five runs are in the form of a tetrahedron, one run at each of the four apices plus one run in the body of the figure.

An alternate design would be a standard 2^3 factorial experiment also shown in Figure 9. This design is in the form of a cube. It should be noted that the cube is actually composed of two tetrahedrons similar to the previous design.

Although the tetrahedron has fewer runs than the cube and is "rotatable", it should not be used whenever interactions either do exist or can possibly exist among the three experimental factors. Replication of at least one of the experimental points in each design is necessary in order to assess the response for lack of fit to the linear model.

For three factor designs capable of fitting a second degree equation there are a limited number of designs. The equation is as follows:

$$y = b_o + b_1x_1 + b_2x_2 + b_3x_3 + b_{11}x_1^2 + b_{22}x_2^2 + b_{33}x_3^2 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 .$$

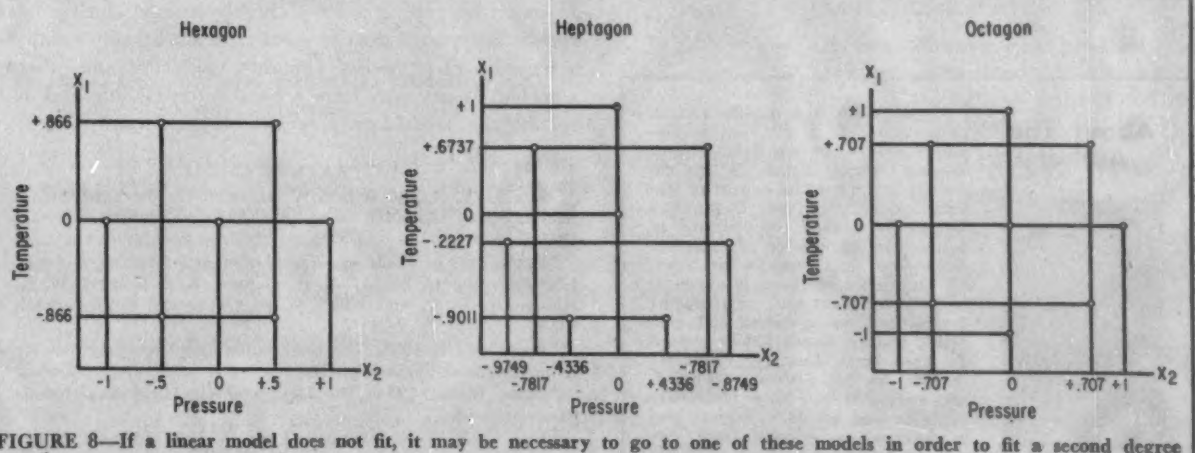


FIGURE 8—If a linear model does not fit, it may be necessary to go to one of these models in order to fit a second degree equation.

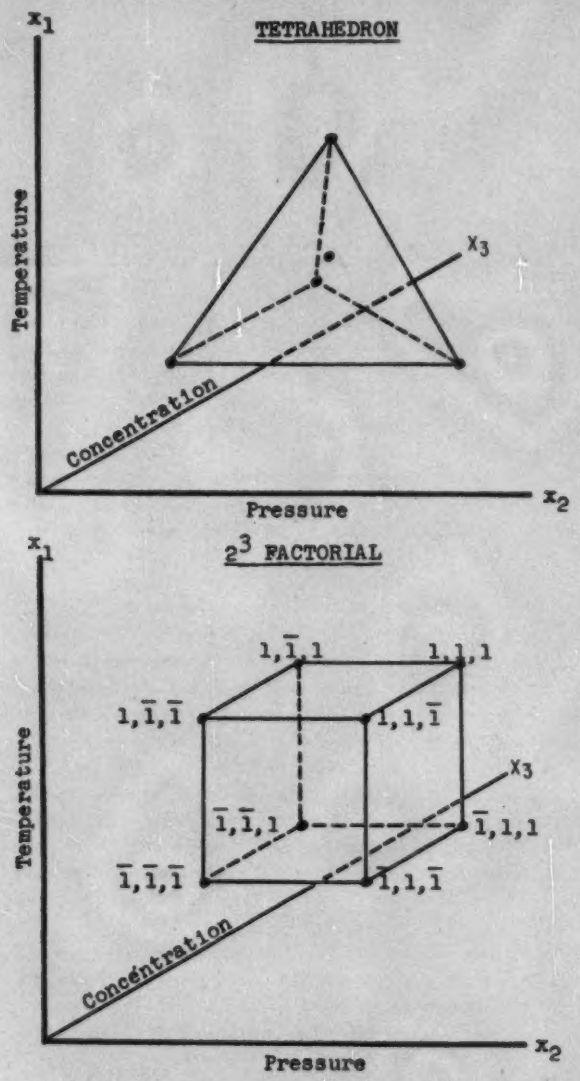


FIGURE 9—Here are some models for fitting a three factor system to a first order equation.

Some of these designs may be composed of a basic cube with an experimental run at each corner plus one run in the center of the cube. In addition to these nine basic runs, additional runs are made outside the body of the cube.

For "rotatable" designs in three factors, regular solids such as the icosahedron or dodecahedron could be used. The icosahedron would consist of the thirteen runs, one at each of the 12 corners or apices of its twenty triangular faces plus one run in the center. The dodecahedron would consist of 21 runs, one at each of the twenty apices of its twelve pentagon faces plus one run in the center.

For experimental designs with more than three factors, there is no way to visualize the hyper-solid represented thereby. In spite of this handicap, multifactor designs exist and can be laid out in tabular form very readily.

As an example, Table 2 shows the design matrix for a four factor experiment. Here is a design in 25 runs which in four experimental dimensions is analogous to the central composite design previously covered for three experimental dimensions. An alternate to this design would be a standard 3^4 factorial experiment of 81 runs which is either approaching or beyond the breaking point for selling to production people.

In conclusion, I wish to emphasize, as I did in the beginning, that the time to design an experiment is before the experiment has begun. It is hoped that through this paper you have been given some insight into the Box Design technique.

If your curiosity has been sufficiently aroused to pursue the subject further, you will discover for yourself its remarkable ability to explore and to exploit response surfaces to optimum advantage. The details of the calculations necessary to determine a path of steepest ascent, surface fitting, and canonical reduction can be found in the attached references. You do not have to be a statistician to use the Box method intelligently and you will profit immeasurably from its use.

To quote from Dr. Walter Shewhart, the first to apply statistics and statistical methods to industrial processes: "The long range contribution of statistics depends not so much on getting a lot of highly trained statisticians into industry as it does in creating a statistically minded generation of physicists, chemists, engineers, and others who will in any way have a hand in developing and directing the production processes of tomorrow."

About The Author

Hugh Smith is a quality control engineer for E. I. du Pont de Nemours & Co., at the Sabine River Works, Orange, Texas. In this capacity, Smith's duties consist of statistical quality control of manufacturing processes, specializing in design and analysis of experiments. Aside from four years in the Navy, his experience has been in chemical engineering plant and equipment design, process problems and economic studies. Smith has been with du Pont since January, 1946. He received his B.E. degree in chemical engineering from Tulane University in 1939, and his M.S. degree, also in chemical engineering, from Virginia Polytechnic Institute in 1941.

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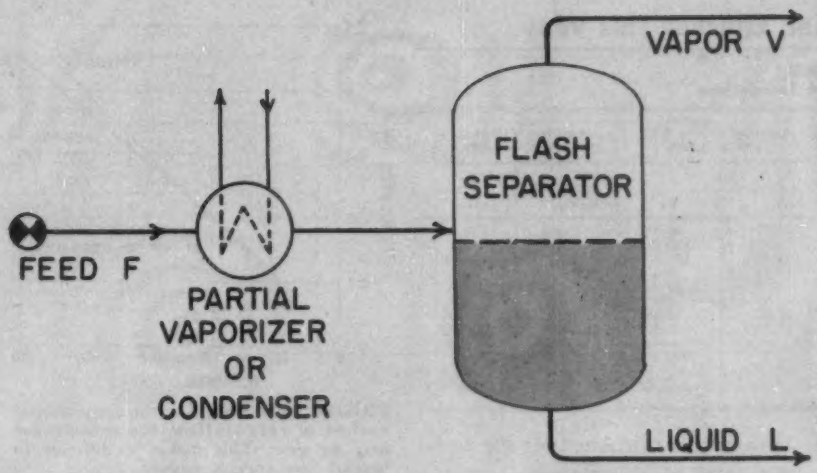

FIGURE 1—A flash equilibrium problem may pertain to partial vaporization or partial condensation of a process stream.

Figure Flash Equilibrium Easier, Quicker This Way

If it seems you always make a bad guess on trial-and-error calculations, try this new method on your next multicomponent flash problem. It will give you the answer faster.

Frank J. Lockhart and Robert J. McHenry
University of Southern California, Los Angeles

HERE IS a method which reduces the usual time and luck required for making flash equilibrium calculations for multicomponent mixtures. The method has the following characteristics:

- It reduces a multicomponent mixture to a hypothetical binary system;
- It is accurate;
- It requires a short and easily computable addendum to the conventional flash calculation;
- The correct answer is bracketed on the very first trial;
- Calculated results of the first trial can be used directly in the second trial (i.e., the method can be one of successive approximation, if desired);
- Convergence to the correct answer is very sharp, and is equivalent to the intersection of two lines at an angle of never less than 45°;
- Convergence to the correct answer is rapid, with practically all problems being solved in three trials.

This new method is an addendum to the conventional flash calculation, and is presented in terms of the particular flash equations preferred by the authors. This does not preclude its use with the various other arrangements of the flash equation.

CONVENTIONAL CALCULATIONS

The typical flash equilibrium as shown in Figure 1 may be one of partial vaporization or partial condensation of a process stream. In process design, the usual problem is to determine the amounts and compositions of the liquid and vapor leaving the flash separator, knowing the amount and overall composition of the feed and the temperature and pressure of the separator. From the given data, the liquid-vapor equilibrium ratio can be obtained for each component, so the starting point in the calculation is the amount and composition of the feed and the liquid-vapor equilibrium ratios.

Two Phases Must Be Present. The arbitrary selection of a temperature and pressure for the flash separator can at times result in zero liquid or zero vapor formation. In order to have some vapor present, it is necessary that the inequality in the bubble-point calculation be satisfied:

$$\Sigma K_n F_n > \Sigma F_n \qquad (1)$$

In order to have some liquid present, it is necessary that the inequality in the dew-point calculation be satisfied;

$$\Sigma F_n/K_n > \Sigma F_n \qquad (2)$$

A legitimate flash equilibrium problem requires that *both* Equations (1) and (2) be satisfied.

If two phases are present, the assumption of steady-state operation gives the material balance on an over-all basis as:

$$F = L + V \qquad (3)$$

and for any component "n," as:

$$F_n = L_n + V_n \qquad (4)$$

The second assumption, of equilibrium between liquid and vapor leaving the flash separator, gives:

$$(V_n/V) = K_n (L_n/L) \qquad (5)$$

This assumption is usually correct for actual liquid-vapor separators, except for kettle-type reboilers and certain types of partial condensers.

TABLE 1
Conventional Calculations

Component	F_n	K_n	Assume V/F = 0.27 (L/V = 2.705) $\frac{L}{K_nV}+1$	Assume V/F = 0.27 (L/V = 2.705) V_n	Assume V/F = 0.20 (L/V = 4.00) $\frac{L}{K_nV}+1$	Assume V/F = 0.20 (L/V = 4.00) V_n
Methane	163.9	3.80	1.711	95.9	2.052	79.9
Ethane	369.5	1.76	2.537	145.6	3.27	113.2
Propane	450.0	0.79	4.42	101.7	6.06	74.3
Isobutane	74.1	0.44	7.14	10.4	10.1	7.3
nButane	239.9	0.35	8.73	27.5	12.43	19.3
Isopentane	56.6	0.195	14.87	3.8	21.5	2.6
nPentane	59.3	0.160	17.90	3.3	26.0	2.3
Hexanes	71.4	0.075	37.02	1.9	54.3	1.3
Total	1484.7			390.1		300.2
	Calculated V/F			0.263		0.203

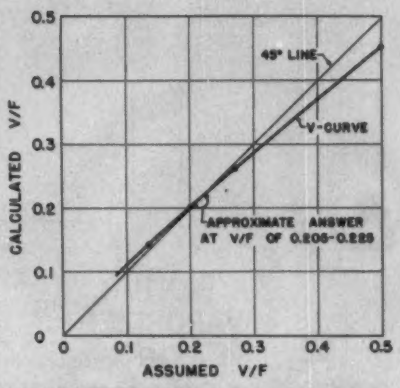

FIGURE 2—When using the conventional method of calculation, the convergence may be slow. This makes it difficult to bracket the correct answer.

The substitution of Equation (4) into Equation (5) for V_n and rearrangement gives:

$$L_n = \frac{F_n}{\frac{K_nV}{L}+1} \qquad (6)$$

If this substitution be made for L_n, rearrangement gives:

$$V_n = \frac{F_n}{\frac{L}{K_nV}+1} \qquad (7)$$

Mathematically then, Equations (6) and (7) are equivalent.

For slide-rule work, it is found better to use Equation (6) when L is less than V, and to use Equation (7) when V is less than L. Solving for the smaller quantity instead of the larger can give one additional figure.

Equation (7) is used in the conventional trial-and-error method by assuming a value of V, calculating L by Equation (3), and then calculating the individual V_n's by Equation (7). The true value of V is found if the ΣV_n equals the assumed value of V. After this checkback, the value of L_n is obtained from Equation (4) for each component, and the mol fractions can be calculated for the liquid and vapor, if desired.

An example of the use of Equation (7) is indicated in Table 1, but not worked out completely. It is noted that the calculated value of V as compared with the assumed value shows the direction of the correct V, but gives no indication whatsoever of how far away the correct answer is. Convergence to the correct answer may be rapid or relatively slow. Figure 2 illustrates the slow convergence of this example, and shows the necessity of bracketing the correct answer.

For a binary mixture of components A (the more volatile) and B (the less volatile), the conventional flash equations simplify into an equation which can be solved directly for V:

$$V = \frac{F_A}{1-K_B} - \frac{F_B}{K_A-1} \qquad (8)$$

The simplicity of Equation (8) caused us to investigate its possible modification for use in solving flash equilibrium calculations of multicomponent mixtures.

TABLE 2
Reduction to a Binary System

Assumed V/F	Conventional Calculation		Added Calculation Using Sub-Totals	
0	$\sum K_nF_n$	(1)	$K^* = \frac{\sigma K_nF_n}{\sigma F_n}$	(10)
1	$\sum\left(\frac{F_n}{K_n}\right)$	(2)	$K^* = \frac{\sigma F_n}{\sigma(F_n/K_n)}$	(11)
0.5	$\sum L_n = \sum\left(\frac{F_n}{(K_n+1)}\right)$	(6)	$K^* = \left[\frac{\sigma F_n}{\sigma\left(\frac{F_n}{K_n+1}\right)}\right] - 1$	(12)
Between 0.5 and 1.0	$\sum L_n = \sum\left(\frac{F_n}{\frac{K_nV}{L}+1}\right)$	(6)	$K^* = (L/V)\left(\frac{\sigma F_n}{\sigma L_n} - 1\right)$	(13)
Between 0 and 0.5	$\sum V_n = \sum\left(\frac{F_n}{\frac{L}{K_nV}+1}\right)$	(7)	$K^* = \frac{(L/V)}{\left(\frac{\sigma F_n}{\sigma V_n} - 1\right)}$	(14)

Note: The equations for K* gives values for K_l^* when the light components are used, and K_h^* when the heavy components are used. These values are used in Equation (9) to obtain V* corresponding to the assumed V.

REDUCTION OF THE MULTICOMPONENT MIXTURE TO A HYPOTHETICAL BINARY MIXTURE

Equation (9) is written for multicomponent mixtures arbitrarily in form similar to Equation (8):

$$V^* = \frac{F_l}{1-K_h^*} - \frac{F_h}{K_l^*-1} \qquad (9)$$

The multicomponent feed F is resolved into mols of "light" component F_l and mols of "heavy" component F_h by classifying the individual components with K_n of one or more as "light," and those with K_n of less than one as "heavy."

K_l^* and K_h^* are evaluated by simple calculations involving the subtotals for the "light" and "heavy" components, as given by Equations (10) through (14) in Table 2. These equations, which are mathematically correct at the corresponding values of the assumed V/F, can be used in a number of ways to speed up the solution of a multicomponent flash problem. Two possible procedures are given below, but these can be modified to suit personal preference.

Procedure No. 1 is illustrated by the calculations in Table 3 and the graph of Figure 3. Calculations are made at assumed V/F values of 0, 1, and 0.5. The assumed V/F values of 0 and 1 correspond to the bubble point and dew point calculations, and are used often in conventional methods when it is not obvious by inspection that the problem is within the two-phase region. The new calculations added here are the sub-totals of the "light" and "heavy" components, the calculation of K_l^*, K_h^*, and V* for each assumed V. The calculations have

TABLE 3
Procedure No. 1

Component	F_n	K_n	At V/F = 0 Eqn. (1) F_nK_n	At V/F = 1 Eqn. (2) F_n/K_n	At V/F = 0.5 Eqn. (6) $F_n/(K_n + 1)$
Methane	163.9	3.80	622.5	43.1	34.2
Ethane	389.5	1.76	651.0	210.0	134.0
σ "Light"	533.4		1273.5	253.1	168.2
Propane	450.0	0.79	355.3	570.0	251.5
Isobutane	74.1	0.44	32.6	168.4	51.5
nButane	239.9	0.35	84.0	686.0	177.7
Isopentane	56.6	0.195	11.1	290.2	47.4
nPentane	59.3	0.160	9.5	370.7	51.1
Hexanes	71.4	0.075	5.4	951.	66.4
σ "Heavy"	951.3		497.9	3036.3	645.6
Total	1484.7		1771.4	3289.4	813.8
			$K_1^* = 2.39$ Eqn. (10)	2.11 Eqn. (11)	2.17 Eqn. (12)
			$H_h^* = 0.523$ Eqn. (10)	0.314 Eqn. (11)	0.475 Eqn. (12
			1118.	778.	1016.
			—685.	—858.	—814.
		$V^* =$	433. Eqn. (9)	—80. Eqn. (9)	202. Eqn. (9)
		$V^*/F =$	0.292	—0.0539	0.136

been converted at the end of Table 3 to the basis of per mol of feed for convenience in preparing Figure 3, although this does not need to be done.

Figure 3 shows the graph of the V* curve, and the approximate answer obtained by its intersection with the 45° line. This answer is called "approximate" because the three calculated points are so far apart that they do not define the exact curvature of the V* curve in all cases. This approximate answer is usually correct to within a range of ±0.02 in V/F. The true answer can be found usually in one more trial and never more than two trials by using Equations (6) and (13) with (9) for small amounts of liquid, or Equations (7) and (14) with (9) for small amounts of vapor.

General observations of this calculation technique can be helpful in saving time:

(1) K_1^* is always larger than one, and K_h^* is always less than one;

(2) Values of K* are largest at the assumed V/F of zero, and smallest at the assumed V/F of one;

(3) V*/F can be greater than one except at the assumed V/F of one;

(4) V*/F can be less than zero except at the assumed V/F of zero;

(5) The V* curve may be concave up or down, but does not have an inflection point. The closer it is to being linear, the more accurate is the approximate answer;

(6) The V* curve is always sloped between 0° and —90°. There is at least a 45° angle between the V* curve and the 45° line;

(7) For true binary mixtures, the V* curve is a horizontal line. Some multicomponent mixtures can approach this condition.

(8) Grouping a component with K of one in with the "heavy" instead of the "light" component shifts the slope of the V* curve, but does not change its intersection with the 45° line;

(9) For each calculation at an assumed V, the calculated V* and the assumed V bracket the correct answer;

(10) For each calculation at an assumed V, the calculated V by the conventional method is different from the calculated V*, and these two bracket the correct answer. Only at the correct V do these two become equal to each other, and also equal to the correct V.

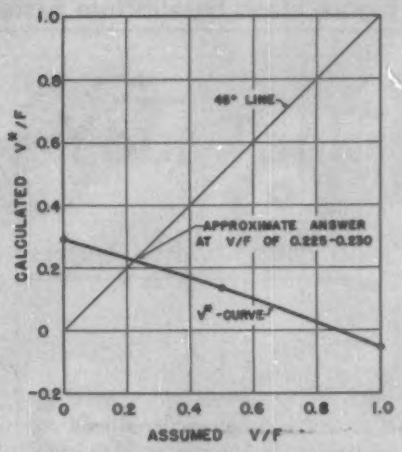

FIGURE 3—In this new method, the convergence to the correct answer is very sharp. It is equivalent to the intersection of two lines at an angle of never less than 45°.

Procedure No. 2 is illustrated by the calculations shown in Table 4 and the graph of Figure 4. When it is known without calculation that the problem is within the two-phase region, the first trial can be made at some arbitrarily selected value of V. The ease of calculation of the three

TABLE 4
Procedure No. 2

Component	F_n	K_n	At V/F = 0.5 Eqn. (6) $F_n/(K_n + 1)$	Try V/F = 0.136 Eqn. (7) $\frac{L}{K_nV} + 1$	Try V/F = 0.136 Eqn. (7) V_n	Try V/F = 0.220 Eqn. (7) $\frac{L}{K_nV} + 1$	Try V/F = 0.220 Eqn. (7) V_n	Eqn. (4) L_n
Methane	163.9	3.80	34.2	2.67	61.4	1.933	84.9	79.0
Ethane	389.5	1.76	134.0	4.61	80.1	3.012	122.7	246.8
σ "Light"	533.4		168.2		141.5		207.6	
Propane	450.0	0.79	251.5	9.05	49.8	5.49	82.1	367.9
Isobutane	74.1	0.44	51.5	15.44	4.8	9.00	8.2	65.9
nButane	239.9	0.35	177.7	19.15	12.53	11.13	21.6	218.3
Isopentane	56.6	0.195	47.4	33.55	1.7	19.18	3.0	53.6
nPentane	59.3	0.160	51.1	40.7	1.5	23.15	2.6	56.7
Hexanes	71.4	0.075	66.4	85.7	0.8	48.3	1.5	69.9
σ "Heavy"	951.3		645.6		71.1		119.0	
Total	1484.7		$\Sigma L_n = 813.8$		$\Sigma V_n = 212.6$		$\Sigma V_n = 326.6$	1158.1
Calculated V/F			0.452		0.143		0.220	
K_1^*			2.17 Eqn. (12)		2.30 Eqn. (14)		2.26 Eqn. (14)	
K_h^*			0.475 Eqn. (12)		0.514 Eqn. (14)		0.506 Eqn. (14)	
			1016.		1098.		1081.	
			— 814.		— 732.		— 755.	
V^*			202. Eqn. (9)		366. Eqn. (9)		326. Eqn. (9)	
V^*/F			0.136		0.2465		0.219	

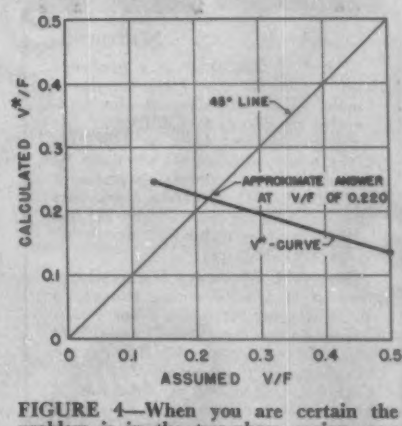

FIGURE 4—When you are certain the problem is in the two-phase region, you may start the first trial at some arbitrarily selected value of V.

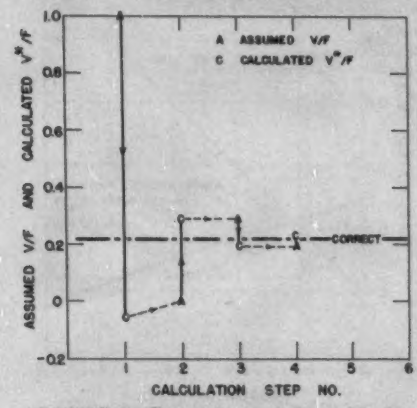

FIGURE 5—Even when starting with the worst possible guess, convergence to the correct answer is very rapid.

points given in Table 3 suggests that one of these (i.e., at assumed V/F of 0, 1, or 0.5) be used as the first trial. When in doubt, use V/F of 0.5 as the first trial because it can be used satisfactorily for either large or small values of the correct answer. The V* calculated in the first trial always overshoots the true V, so it can be used as the assumed V for the second trial. Table 4 shows this type of calculation sequence, and Figure 4 indicates the intersection of the V* curve and the 45° line to be the approximate answer. This is called the "approximate" answer, but it has been observed to be close enough to the correct answer in practically all cases. The third trial is made at the V corresponding to this intersection, and checks out satisfactorily as shown in Table 4. The corresponding L_n is obtained from Equation (4) for each component, and the mol fractions can be calculated if desired.

Some may prefer a slight modification of Procedure No. 2 after the first trial. Realizing that the V* calculated on the first trial overshoots the true V, the second trial can be made at an assumed V of 75 percent of the distance between the assumed V and the calculated V* of the first trial.

Convergence Is Rapid. Figures 3 and 4 indicate that this new method should converge rapidly to the correct answer. Figure 5 shows this to be true, even when starting with the worst possible guess. The calculated V*/F was used for the next calculation step (except that the assumed V/F must always be between 0 and 1), and interpolation such as used in Figures 3 and 4 was not used. Despite these handicaps, the V*/F on the fourth step was calculated to be 0.224, about 0.004 higher than the correct answer. The fifth calculation step would give the answer correctly for all practical purposes. The damping effect has been equally rapid as that shown in Figure 5 for all cases tried.

The time required to obtain the correct answer by this method depends upon the number of components and the working speed of the individual. But in most problems, the time required will be considerably less than that used in the conventional calculations because the element of luck in making good first guesses has been eliminated.

The eight component problem used as the example here was suggested by an experienced process engineer. Knowing only the feed composition F_n and the K_n values, the senior author used Procedure No. 2 as given in Table 4, made the necessary calculations and completed Figure 4 in a time of 12 minutes. The entire calculations shown in Table 4 were completed within 20 minutes.

Other applications are possible for this method. It can be used to advantage in making adiabatic flash calculations, the construction of the entire flash curve, and in problems of determining the temperature and pressure which will give a certain amount of vapor and liquid from a given feed.

The use of Procedure No. 1 with new values of K_n for different conditions of temperature and pressure enables an entire flash curve to be calculated very quickly with an accuracy of within ±0.02 in V/F. This is probably within the accuracy of the K_n values themselves.

An alternate approach is to use Procedure No. 1 at one condition of temperature and pressure, and then to make normal allowance for the change of each of the six K*'s with change to another condition of temperature and pressure. This requires interpolation on the conventional K_n charts. Such an approach can be very fast for mixtures containing a large number of components, but is less accurate than Procedure No. 1. However, it can be a time-saver in finding the right range of temperature and pressure.

Conventional Nomenclature

- $F = \Sigma F_n$ — total mols of feed entering the flash separator
- F_n — mols of component "n" in the feed
- $K_n = y_n/x_n$ — liquid-vapor equilibrium ratio of component "n" at the temperature and pressure of the flash separator
- $L = \Sigma L_n$ — total mols of liquid leaving the flash separator
- L_n — mols of component "n" in the liquid
- $V = \Sigma V_n$ — total mols of vapor leaving the flash separator
- V_n — mols of component "n" in the vapor
- x_n — mol fraction of component "n" in the liquid $= L_n/L$
- y_n — mol fraction of component "n" in the vapor $= V_n/V$
- Σ — summation for all components present in the mixture

New Nomenclature

- F_l — total mols of components in the feed with K_n equal to or greater than one, defined as the "light" component
- F_h — total mols of components in the feed with K_n less than one, defined as the "heavy" component
- K_l^* — so-called equilibrium ratio for the "light" component in the hypothetical binary mixture
- K_h^* — so-called equilibrium ratio for the "heavy" component in the hypothetical binary mixture.
- V^* — mols vapor calculated by Equation (9) for the flash equilibrium of the hypothetical binary mixture
- σ — sub-totals for the "light" component and the "heavy" component

# #

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Frank J. Lockhart is a professor and head of the Department of Chemical Engineering at the University of Southern California, Los Angeles. He has been at USC for eight years, during which time he has acted as a consulting engineer for a number of operating companies and engineering contractors. He has had eight years industrial experience as process engineer.

Robert J. McHenry is a graduate student at USC working towards a Ph.D. degree. He is the Fluor Foundation Fellow for 1956-57 and 1957-58. McHenry received a B.S. degree in chemical engineering from the Catholic University of America in May, 1956, and an M.S. degree in chemical engineering from USC in 1957.

Take a look at . . .

Bolted Clean-Out Doors For Your Tanks

A new look in clean-out doors has just been developed with a bolted door that will not leak and is safe from stress.

R. W. Bodley and R. C. Ulm
Graver Tank and Manufacturing Company, Incorporated
East Chicago, Ind.

ACCESS DOORS into large tanks are desirable in the storage of certain types of products, especially where clean-out of bottom settlings is necessary. In the past, these openings have been in the form of either riveted door plates or manway-type openings with bolted covers. The bolted doors, which are the subject of this article, are similar in design to the well known riveted type (of which many hundreds have been installed) in that the door-plate is fastened directly to the shell-plate. The riveted types are not used extensively at present because it is difficult to find riveters to replace a door once it has been removed.

The development of bolted door-sheet designs was undertaken as a service to the industry, because there was a need and a desire for a large, safe, economical, clean-out door that could be removed and replaced by regular maintenance personnel. They are not patented or proprietary items.

Several oil companies which expressed the need for these designs also expressed the desire that they carry API approval. Therefore, as this development progressed, the findings were presented to the API Manufacturer's Sub-Committee on Standardization of Oil Storage Tanks, which at the present time is considering final designs for possible inclusion in API code 12-C.

Test Results. From the results of these tests, it was concluded that bolted clean-outs can be successfully fabricated and installed, do not leak, and are not too highly stressed.

It is our opinion (based on the repeated tests conducted in the shop on 3/16 inch and 1/4 inch thick plates) that the doors can be removed at least six times without sufficient damage to the holes or bolts to require reaming or new bolts.

Types of Doors. These clean-out doors are of two types: Raised and flush. The raised type is simply an opening cut in the tank shell with a cover plate bolted over it as in the former riveted type. The flush type is similar except that the bottom of the cover plate is bolted to an angle assembly welded to the underside of the tank bottom so that an opening flush with the tank bottom is obtained when the door-plate is removed. The design of a flush-type door bolting directly to the tank shell without any reinforcing pad plate is new to the art in these large sizes.

The bolts used in this new design are American Standard heavy, machined to size and under the head, so that a good fit is obtained and no lip remains under the head. Square bars are placed between the heads of the bolts in adjacent rows on the inside of the tank to keep the bolts from turning during assembly or removal of the door plate. A neoprene putty gasket containing about 80 per cent solids with a specific weight of 12 pounds per gallon is used between the bolting surfaces and around the head of each bolt to seal against leakage.

The door-plate can be initially installed in the field or it can be installed on a shell-plate in the shop, then the plate containing the completed door can be fitted into the tank in the field.

Testing Bolts and Gaskets. As a first step in determining what type of bolts and gaskets would be suitable, six different lapped-type, bolted and riveted joints were made up and tested in a tensile machine. The test assemblies were of 5/16 inch x 10 inch x 23 inch long center plate with 1/4 inch x 10 inch x 12 1/2 inch end plates. Figure 1 shows these assemblies. Before assembly, the bolting surface of each plate was coated with one coat of primer and two coats of neoprene paint except for the riveted joint and joint 1 (b) which contained a 1/8 inch rubber gasket.

The specimens were covered with a brittle lacquer and then tension was applied until yielding was evident in the plates around the bolts.

From the results of this test, it was concluded that:

- Turned bolts in reamed holes distribute the forces equally as well as rivets in this type of construction.
- Tapered pin bolts are not satisfactory because they loosen after the tension is removed.
- The 1/8 inch rubber gasket was not satisfactory because it allowed slippage.

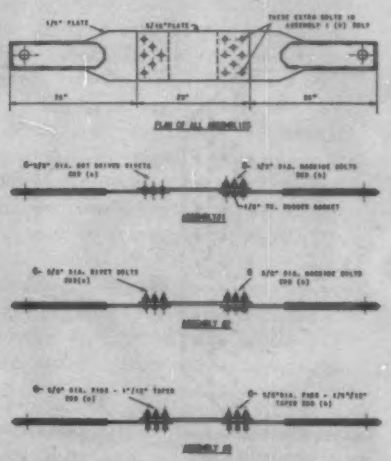


FIGURE 1—Tensil tests of various lap joints indicate that turned bolts in reamed holes work as well as rivets.

FIGURE 2—Test tank designed for three times the head encountered in a 40-foot high storage tank.

- Rivet type bolts (ribbed shanks) are not suitable because they mar the hole in the plate.

Test Doors On a Tank. To further develop bolting and sealing means, tests were run on doors on a 10 foot, 6 inch dia. x 8 foot high tank, which was designed for 50 psi internal pressure. This pressure was selected to simulate at least three times the liquid heads encountered in 40 foot high storage tanks. The tank had a shell 3/16 inch thick, a top made of a 3/8 inch thick dished ASME head and a flat, reinforced bottom. Angle ties connected the upper part of the tank to the bottom reinforcing. Besides economy and convenience, this small tank with its thin shell would be harder to seal against leakage than one of thicker plate, and damage to the holes, if any, would show up more quickly with repeated bolt removal. Figure 2 shows a photograph of this tank.

The tank had two test doors, a *flush* type and a *raised* type spaced 180 degrees apart. Each opening was 4 feet high x 8 feet long and the door plate ¼ inch thick.

Sealing. Four tests of different sealing means were run as follows on both type doors:

Test 1. The bearing surfaces of the door sheets and shell were covered with one coat of neoprene paint upon which a gasket made of roofing paper was placed. The tank was filled with water and the pressure at the top increased hydrostatically to 35 psig. Leaks around five bolts at that pressure occurred at random locations on the conventional door and several leaks on the flush door occurred at the bottom.

Test 2. A 6 inch length of graphited wicking was wrapped around each bolt on the outside of the door-sheet and underneath the washer and nut, in addition to the gasket in Test 1. This method of sealing the bolts worked satisfactorily to a pressure of 49 psig. However, a leak at a joint in the roofing paper gasket occurred at this pressure. The roofing paper gasket was too hard to handle, so other sealing means were sought.

Test 3. Two coats of neoprene paint were applied on each bearing surface of the flush door-sheet and the shell. A neoprene strip 1/16 inch x ¾ inch wide was attached to the raised door plate all around its outer edges. Wicking was wrapped around all bolts on both doors as in Test 2.

The flush door with the four coats of neoprene paint did not leak at 45 psig. The conventional door, with the strip gasket, leaked as a result of water head only.

Test 4. A full face gasket appeared to be necessary, so a search for a thicker paint was launched. A neoprene trowelling compound was found and applied to both bearing surfaces. Wicking was applied to only a few new bolts for purposes of comparison. This was tested to a pressure of 50 psig, which is equal to a water height of approximately 115 feet, and no leaks occurred.

At the conclusion of these four

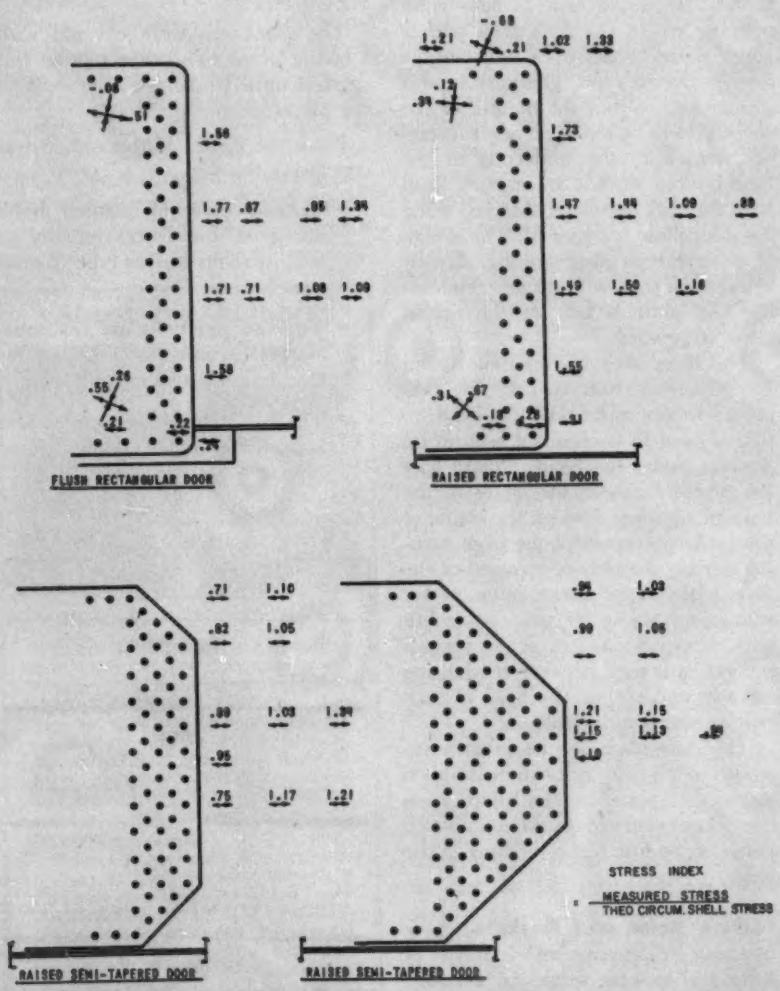


FIGURE 3—Stress indices on test doors show that doors can be bolted without excessive stress concentrations.

tests, sealing was finally accomplished by applying a 1/16 inch coating of neoprene to the 5/16 inch shell and 1/4 inch door-plate.

The same bolts and nuts were used in all four tests and no additional reaming was required to rebolt the door nor was any hole damage observed.

Design. As the method for sealing was being developed, designs of the doors were also being studied. Rectangular doors were used on the first three tests on both the flush and raised types. On the fourth test, a door with a semi-taper on one end and almost a full taper on the other end was used.

Strain gages, both Rosette and A-5, were mounted outside the tank at various positions around the doors with the intention of covering all points of stress concentration. The usual strain gage circuits employing strain indicators were used.

Indicated strains for each gage were plotted against pressure for each of the above tests. Lines were carefully faired through the experimental points. A dashed line parallel to the above lines was drawn through zero and projected to the 50 psig position. Strains corresponding to this pressure were used in the calculations.

Rosette gages were analyzed algebraically to determine principal stresses and directions. Each stress calculated in the above manner was divided by the theoretical circumferential shell stress to give a stress index. Some of these index values are shown in their respective positions on the door-sheets in Figure 3. The arrow shows the directions of the measured stress.

The stress indices for the various tests indicated:

- Near the bottom of the shell, for the raised type door, or on the bottom angle for a flush type door, a plate could be satisfactorily bolted without any stress concentration.
- Along the top of the plate and near the upper corners, the stresses were transmitted from the door to the shell with a stress build-up of less than 21,000 psi.
- Excessive stress concentrations were present in the shell at the ends of the rectangular sheets. This could be reduced by fully tapering the sheets.

Field Tests. Since the foregoing preliminary tests yielded favorable results, a program of installing and testing these door-sheets on field-erected tankage was undertaken. Two raised-type and two flush-type doors were installed. The raised doors were 4 feet x 6 feet installed in a 140 foot diameter, center-weighted, floating roof tank. One of these was strain gage tested. The flush doors were also 4 feet x 6 feet. One was installed in a 67 foot dia. x 40 foot cone roof tank and the other in a 100 foot dia. x 40 foot cone roof tank. Both were strain gage tested.

Installation. The two raised-type doors were bolted to the shell-plate in the field. The flush-type doors were assembled to the shell plate and bottom girder in the shop, and this assembly was then welded into the first ring of the shell in the field. Both methods worked well. On the shop-assembled units, stiffening angles were tacked to the shell-plate to protect the assembly during shipment.

American Standard, milled-body machine bolts with heavy hexagon heads and heavy hexagon nuts were used. The holes were drilled 1/8 inch undersize and then reamed to the exact bolt diameter, after the door was "fit-up." Square bars bearing against the bolt heads were tack welded to the shell inside, to prevent the bolts from turning during assembly or removal. Tacks were placed directly opposite the bolt heads, to prevent the bar from bending and allowing the bolt to turn.

The door was then removed, the bearing surfaces were brushed free of dirt and scale and a gasket of neoprene, trowelling compound accelerator, about 1/16 inch thick, was applied to the bearing surface of the door only. This is in contrast to the small tank tests in which the compound was placed on both bearing surfaces. The compound was applied with a saw toothed applicator similar to one used for spreading lineoleum paste (See Figures 4 and 5). A fillet of this compound was placed around the shank, at the head of each bolt, before the bolts were inserted into the holes. About 12 pounds of this compound was used for each door. The bolts were tightened with an air wrench. Figure 6 shows a door bolted in place.

Testing. The strain gages were mounted in the same manner as that described above for the small tank tests, except that the gages were mounted both inside and outside the shell, opposite each other, so that average membrane stresses could be obtained. Also, in the case of the A-5 gages, two gages were mounted at right angles to each other, one horizontally and one vertically at each location. The normal solution for the case of strains in tension or compression in two perpendicular directions was used in analyzing the results from these gages. Wood frame sunshades were built around the sheets to protect the gages from direct sunlight and thereby minimized the chances for large errors in measured stresses resulting from high temperature gradients.

Careful and repeated observations indicated that there were no leaks on any of the doors.

Indicated strains were handled in a manner similar to that described

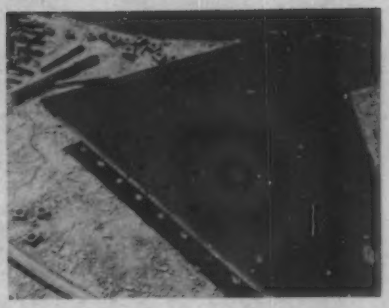
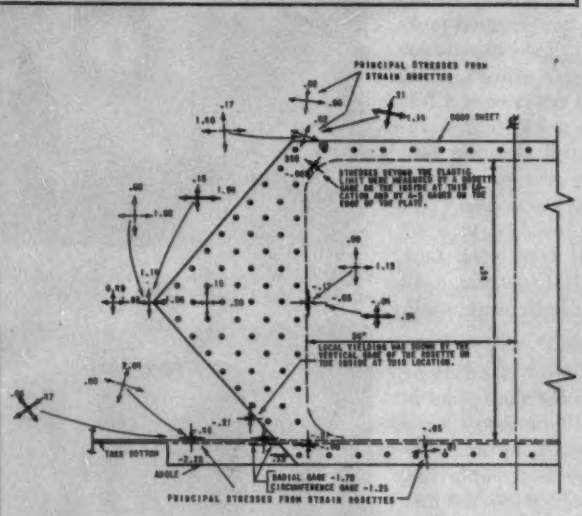


FIGURE 4—Neoprene gasket is trowelled on door and allowed to become tacky.

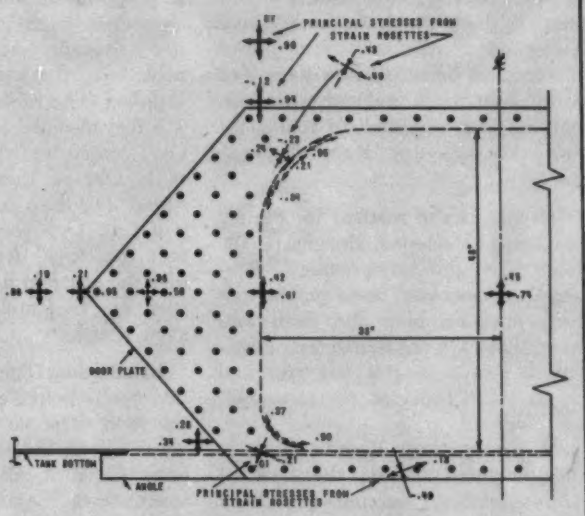
FIGURE 5—Mill scale is ground off the shell plate around the clean-out opening.

FIGURE 6—Clean-out door bolts are tightened with an air wrench.



Note: Stress indices in a 4-foot by 6-foot flush type cleanout on a 67-foot diameter by 40-foot high tank. Dashed arrows refer to stresses measured on the inside of the tank. Solid arrows show gage location and refer to stresses measured on the outside of the tank. Where a double line is used the arrows refer to the membrane or average stress. Numbers are stress indices i.e. measured stresses divided by the nominal theoretical hoop stress one foot above the tank bottom. Negative signs indicate compression.

FIGURE 7—The upper corner of the shell plate was stressed beyond the elastic limit in one test.



Note: Stress indices in a 4-foot by 6-foot flush type cleanout on a 100-foot diameter by 40-foot high tank. Dashed arrows refer to stresses measured on the inside of the tank. Solid arrows show gage location and refer to stresses measured on the outside of the tank. Where a double line is used the arrows refer to the membrane or average stress. Numbers are stress indices i.e. measured stresses divided by the nominal theoretical hoop stress one foot above the tank bottom. Negative signs indicate compression.

FIGURE 8—The shell plate radius was increased which relieved the high stress concentrations of the previous tests.

above for the small tank tests. In this case, the stress indices were obtained by dividing the measured stress by the theoretical circumferential shell stress at a point one foot above the tank bottom.

In general, the results of this investigation showed that the measured values of stress were consistent with what would be expected from theoretical considerations. The measured circumferential membrane stress was near the calculated value in the shell-plate and door-sheet.

Stresses near the bottom were generally low. This was expected since the bottom plates take some of the tension and consequently, lowers the hoop stress in that region. However, considerable vertical compressive stress (80 percent of the nominal hoop stress) was measured near the bottom on one test. This is consistent with what we expected from a consideration of the expansion of the shell above the constraint at the bottom.

A Rosette gage on the shell plate, close to the upper curved corner of the opening, showed high stress concentration in that area on the first test and strains above the elastic limit on the second test. Stress indices showing this for Test 2 are plotted in position on Figure 7. To alleviate this condition, the upper corner radius was increased from 6 inches to 16 inches for Test 3. Indices for this test are shown plotted in Figure 8. Study of this figure shows that the high stress concentration was relieved.

Bolted Door Design. The design of the test doors described above was based on an 85 percent joint efficiency with an allowable stress of 21,000 psi. in the plate. Because of possible damage to the holes by repeated removal of the door, the API committee requested that the joint efficiency be increased to 90 percent to allow for additional reaming.

The design rules which follow call for a 90 percent efficiency and represent the latest data submitted to the API. The tabulations (Figures 9 and 10 and Tables 1 and 2) are for doors 4 feet high by 8 feet long. Other sizes may be calculated as desired. The door plate in the tabulation is thicker than the shell-plate because less steel is required than for plates the same thickness as the tank shell. Other door-plate thicknesses and bolt arrangements can be safely used if the following rules are met.

Rules.

1. The strength of the bolted joint should be equal to at least 90 percent of the full strength of the unbolted plate.
2. Maximum tensile stress in net section or door-plate equals 21,000 psi.
3. Maximum shear stress in gross section of bolt equals 16,000 psi.
4. Maximum bearing stress on plate or bolts equals 32,000 psi.
5. The minimum net cross-sectional area of the door-sheet, excluding the tapered ends, shall not be less than the product of the shell-plate thickness and the vertical height of the cutout in the tank shell plus twice the bolt-hole diameter.
6. Provide sufficient bolts to transmit

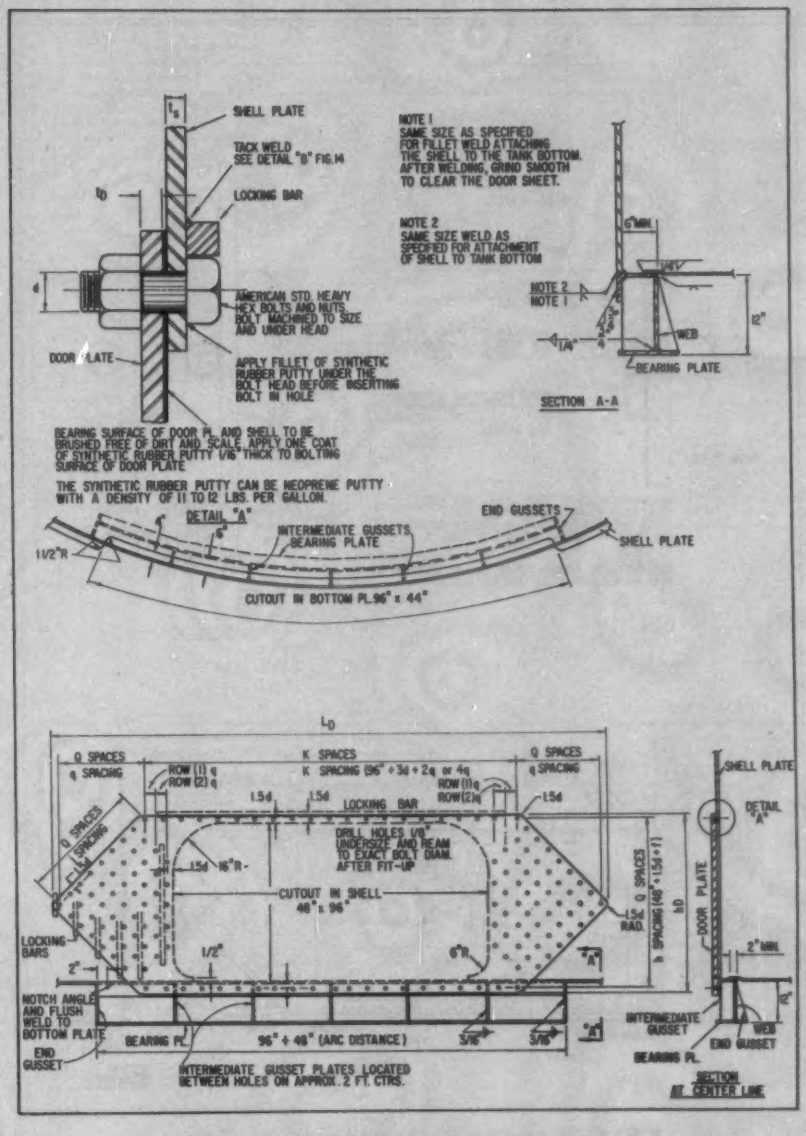

SHELL PLATE
TACK WELD SEE DETAIL "B" FIG. 14
LOCKING BAR
AMERICAN STD. HEAVY HEX BOLTS AND NUTS, BOLT MACHINED TO SIZE AND UNDER HEAD
DOOR PLATE
APPLY FILLET OF SYNTHETIC RUBBER PUTTY UNDER THE BOLT HEAD BEFORE INSERTING BOLT IN HOLE
BEARING SURFACE OF DOOR PL. AND SHELL TO BE BRUSHED FREE OF DIRT AND SCALE. APPLY ONE COAT OF SYNTHETIC RUBBER PUTTY 1/16" THICK TO BOLTING SURFACE OF DOOR PLATE
THE SYNTHETIC RUBBER PUTTY CAN BE NEOPRENE PUTTY WITH A DENSITY OF 11 TO 12 LBS. PER GALLON.
NOTE 1
SAME SIZE AS SPECIFIED FOR FILLET WELD ATTACHING THE SHELL TO THE TANK BOTTOM. AFTER WELDING, GRIND SMOOTH TO CLEAR THE DOOR SHEET.
NOTE 2
SAME SIZE WELD AS SPECIFIED FOR ATTACHMENT OF SHELL TO TANK BOTTOM
WEB
BEARING PLATE
SECTION A-A
DETAIL "A"
INTERMEDIATE GUSSETS
END GUSSETS
SHELL PLATE
CUTOUT IN BOTTOM PL. 96" x 44"
Q SPACES
q SPACING
K SPACES
ROW (1) q
ROW (2) q
LOCKING BAR
DRILL HOLES 1/8" UNDERSIZE AND REAM TO EXACT BOLT DIAM. AFTER FIT-UP
CUTOUT IN SHELL 48" x 96"
LOCKING BARS
NOTCH ANGLE AND FLUSH WELD TO BOTTOM PLATE
END GUSSET
BEARING PL.
96" + 48" (ARC DISTANCE)
INTERMEDIATE GUSSET PLATES LOCATED BETWEEN HOLES ON APPROX. 2 FT. CTRS.
DOOR PLATE
2" MIN.
SECTION AT CENTER LINE

FIGURE 9—Raised-type bolted door sheets. (See Table 1)

to the door plate, by shear, 90 percent of the full strength of the unbolted shell-plate.

7. The bolts can be arranged in various patterns providing the arrangement produces tapered ends. The minimum distance between centers of bolt holes shall be at least three times the nominal diameter of the bolt. The tensile stress of the net plate in the first row of bolts next to the shell opening shall not exceed 21,000 psi and in subsequent rows shall not exceed 21,000 psi less the total shearing value or bearing value (whichever is less) of the bolts in the preceding row or rows. (In certain cases, where thinner plates are encountered, the bearing value may govern and should be checked.) Bolt spacing at the sealing edge of the plate shall not exceed seven times the minimum door-sheet thickness (plus washer thickness if washers are used) plus the nominal diameter of the bolt.

From the above:

Flush type door $N = \dfrac{t_s\,(h_c + 2.5d + f) \times 21{,}000 \times 0.90}{A \times 16{,}000}$

Raised type door $N = \dfrac{t_s\,(h_c + 4d) \times 21{,}000 \times .90}{a \times 16{,}000}$

$$t_D = \frac{t_s\,(h_c + 2d)}{h_D - (N_1 d)}$$

Where:

N = Number of bolts required at each end of opening
t_s = Shell-plate thickness, inches
t_d = Door-plate thickness, inches
h_D = Height of door-plate, inches
h_c = Height of shell cutout, inches
d = Diameter of bolt and bolt holes, inches
a = Area of bolt and bolt holes, square inches
N_1 = Maximum number of bolts in any one row.

8. If the difference between the diameter of the bolts and the holes

TABLE 1—Raised-Type Bolted Door-Sheets

See Fig. 9—All Dimensions in Inches

Shell Thickness t	Q	q	h	j	K	k	t_D	h_D	L_D	NO. OF BOLTS Row 1	Row 2	Total	Dia. of Bolt d	Length of Bolt	Bolt Thread Length	Square Locking Bar	Max. Dia. Re-Reamed Hole
3/16	7	1 11/16	7.179	4.080	36	2.837	7/16	52 1/16	131 7/16	5	..	152	3/4	2	1 3/16	3/4	1
1/4	7	1 11/16	7.179	4.080	30	3.404	7/16	52 1/16	131 7/16	7	..	144	3/4	2	1 7/16	3/4	1
5/16	8	1 11/16	6.281	3.691	30	3.404	7/16	52 1/16	135 7/16	8	..	164	3/4	2	1	3/4	1
3/8	8	2 1/16	6.328	3.883	24	4.109	1/2	53 1/16	137 3/8	..	..	136	7/8	2 1/16	1 3/16	3/4	1 1/16
7/16	8	2 1/16	6.328	3.883	22	4.688	1/2	53 1/16	142 3/8	6	..	144	7/8	2 1/16	1 1/16	3/4	1 1/16
1/2	8	2 7/16	6.375	4.012	20	4.950	9/16	54	141 5/8	..	..	128	1	2 3/16	1 5/16	3/4	1 1/16
9/16	8	2 7/16	6.375	4.012	20	5.194	9/16	54	146 5/8	4	..	136	1	2 1/16	1 1/16	3/4	1 1/16
5/8	8	2 5/16	6.422	4.309	20	4.969	11/16	54 5/16	149 5/16	..	..	128	1 1/16	2 3/16	1 5/16	1	1 3/16
11/16	8	2 5/16	6.422	4.309	20	5.256	11/16	54 5/16	155 5/16	2	..	132	1 1/16	3	1 1/16	1	1 3/16
3/4	8	3 1/16	6.469	4.453	20	4.988	11/16	55 1/16	153 5/16	..	..	128	1 1/16	3 1/16	1 5/16	1	1 1/16
7/8	8	3 1/16	6.469	4.453	20	4.988	1	55 1/16	153 5/16	..	..	128	1 1/16	3 1/16	1 1/16	1	1 1/16
1	8	3 1/16	6.469	4.453	20	5.294	1 1/16	55 1/16	160 1/16	6	..	140	1 1/16	3 1/16	1 5/16	1	1 1/16
1 1/16	8	3 1/16	6.469	4.453	20	5.600	1 1/16	55 1/16	166 1/4	6	5	154	1 1/16	3 1/16	1 1/16	1	1 1/16
1 1/8	8	3 1/16	6.516	4.602	20	5.656	1 1/16	56 1/4	171	6	3	146	1 1/16	4 1/16	1 5/16	1	1 3/16
1 3/16	8	3 1/16	6.516	4.602	20	5.656	1 1/16	56 1/4	171	8	7	158	1 1/16	4 1/16	1 1/16	1	1 3/16
1 1/4	8	3 1/16	6.563	4.754	20	5.712	1 1/16	57	175 3/4	6	5	150	1 1/16	5	1 1/16	1	1 3/16

NOTE: Use American Standard washers on both sides of plate up to 5/8-inch shell thickness.

TABLE 2—Flush-Type Bolted Door-Sheets See Fig. 10—All Dimensions in Inches

Shell Thickness t	Q	e	h	j	K	k	t_D	k_D	f	L_D	NO. OF BOLTS Row 2	NO. OF BOLTS Row 1	NO. OF BOLTS Total	Diam. of Bolt d	Length of Bolt	Bolt Thread Length	Sq. Lock Bar	Max. Diam. Re-Reamed Hole	Angle	Web	Intermediate Gusset	End Gusset	Bearing Plate
3/16	7	1¼	7.375	4.165	28	2.837	3/16	63/64	2½	132	7	3	136	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
3/16	7	1¼	6.453	3.766	28	2.375	3/16	63/64	2½	133	7	3	136	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
3/16	7	1¼	6.453	3.766	28	2.404	3/16	63/64	2½	135	7	3	136	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
3/16	7	1¼	6.477	3.945	24	4.397	3/16	63/64	2½	143⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
3/16	7	1¼	6.477	3.945	24	4.392	3/16	63/64	2½	145⅞	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.500	4.063	24	5.194	1/4	1	2½	149⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.500	4.063	24	5	1/4	1	2½	149⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.500	4.063	24	5.194	1/4	1	2½	149⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.586	4.371	24	4.899	1/4	1	2½	149⅞	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.586	4.371	24	5.356	1/4	1	2½	150⅛	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.586	4.371	24	4.888	1/4	1	2½	154	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.609	4.504	24	5.394	1/4	1	2½	160	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.609	4.504	24	5.600	1/4	1	2½	166¼	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.633	4.645	24	5.383	1/4	1	2½	164⅜	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.633	4.645	24	5.656	1/4	1	2½	171	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.656	4.785	24	5.713	1/4	1	2½	175⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/4	7	1¼	6.656	4.785	24	5.724	1/4	1	2½	175⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	7.375	4.165	28	2.837	5/16	1 1/16	2½	132	7	3	136	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.453	3.766	28	2.375	5/16	1 1/16	2½	133	7	3	136	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.453	3.766	28	2.404	5/16	1 1/16	2½	135	7	3	136	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.477	3.945	24	4.397	5/16	1 1/16	2½	143⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.477	3.945	24	4.392	5/16	1 1/16	2½	145⅞	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.500	4.063	24	5.194	5/16	1 1/16	2½	149⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.500	4.063	24	5	5/16	1 1/16	2½	149⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.500	4.063	24	5.194	5/16	1 1/16	2½	149⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.586	4.371	24	4.899	5/16	1 1/16	2½	149⅞	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.586	4.371	24	5.356	5/16	1 1/16	2½	150⅛	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.586	4.371	24	4.888	5/16	1 1/16	2½	154	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.609	4.504	24	5.394	5/16	1 1/16	2½	160	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.609	4.504	24	5.600	5/16	1 1/16	2½	166¼	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
5/16	8	1¼	6.633	4.645	24	5.383	5/16	1 1/16	2½	164⅜	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
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5/16	8	1¼	6.656	4.785	24	5.724	5/16	1 1/16	2½	175⅝	6	3	138	¾	3	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
3/8	8	1½	7.375	4.165	28	2.837	3/8	1 3/16	3	132	7	3	136	⅞	3½	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
3/8	8	1½	6.453	3.766	28	2.375	3/8	1 3/16	3	133	7	3	136	⅞	3½	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
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3/8	8	1½	6.477	3.945	24	4.397	3/8	1 3/16	3	143⅝	6	3	138	⅞	3½	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
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1/2	8	1½	6.609	4.504	24	5.600	1/2	1 7/16	3	166¼	6	3	138	⅞	3½	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
1/2	8	1½	6.633	4.645	24	5.383	1/2	1 7/16	3	164⅜	6	3	138	⅞	3½	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19
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1/2	8	1½	6.656	4.785	24	5.724	1/2	1 7/16	3	175⅝	6	3	138	⅞	3½	1⅛	¾	1	6x3½x⅜	¾x11¾	¾x10⅜	¾x10⅜x10⅜	¾x19

* Special length bolts shall be furnished for bolting the bottom of the door sheet to the supporting truss.

NOTE: Use American Standard washers on both sides of plate up to ¾-inch shell thickness.

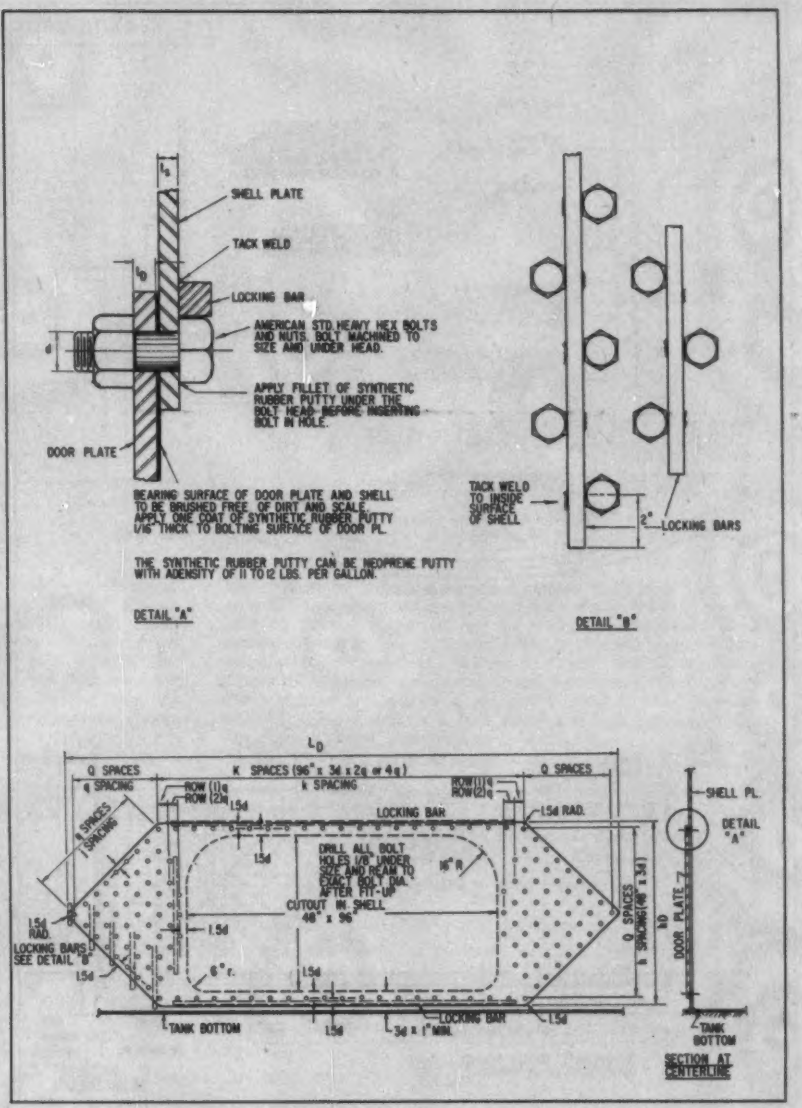
SHELL PLATE
TACK WELD
LOCKING BAR
AMERICAN STD. HEAVY HEX BOLTS AND NUTS BOLT MACHINED TO SIZE AND UNDER HEAD.
APPLY FILLET OF SYNTHETIC RUBBER PUTTY UNDER THE BOLT HEAD BEFORE INSERTING BOLT IN HOLE.
DOOR PLATE
BEARING SURFACE OF DOOR PLATE AND SHELL TO BE BRUSHED FREE OF DIRT AND SCALE. APPLY ONE COAT OF SYNTHETIC RUBBER PUTTY 1/16" THICK TO BOLTING SURFACE OF DOOR PL.
THE SYNTHETIC RUBBER PUTTY CAN BE NEOPRENE PUTTY WITH ADENSITY OF 11 TO 12 LBS. PER GALLON.
DETAIL "A"
TACK WELD TO INSIDE SURFACE OF SHELL
LOCKING BARS
DETAIL "B"
Q SPACES
K SPACES (96" ± 3d ± 2q or 4q)
q SPACING
ROW (1) q
ROW (2) q
LOCKING BAR
1.5d RAD.
DRILL ALL BOLT HOLES 1/8" UNDER SIZE AND REAM TO EXACT BOLT DIA. AFTER FIT-UP
CUTOUT IN SHELL 48" x 96"
16" R
LOCKING BARS SEE DETAIL "B"
6" r.
TANK BOTTOM
3d ± 1" MIN.
SHELL PL.
DETAIL "A"
DOOR PLATE
SECTION AT CENTERLINE

FIGURE 10—Flush-type bolted door-sheets. (See Table 2)

becomes greater than 1/50 inch, because of repeated removal of the door, the holes should be re-reamed to a larger size and new bolts should be provided. The holes should not be reamed beyond the point where the strength of the bolted joint becomes less than 85 percent of the full strength of the unbolted plate.

9. Round all door-plate corners to a minimum radius of 1½d.

10. Bottom girder for flush type door:

(a) The girder to withstand a bending moment which would result if the ends of the girder were on hard ground and the center was unsupported.

(b) Consider the load on the girder to be equal to the weight of a column of water with the dimensions: .03 tank radius x width of shell cutout + 2 feet tank height.

(c) The design length of the girder should be equal to the width of the shell cutout + 2 feet.

(d) In Table 2, the bottom angle thickness is made equal to the shell-plate thickness where possible, so that special length bolts are not required.

ACKNOWLEDGMENT

The authors wish to express their gratitude to the various oil and chemical companies who made the field tests possible and the API Committees on Standardization of Oil Storage Tanks for constructive suggestions.

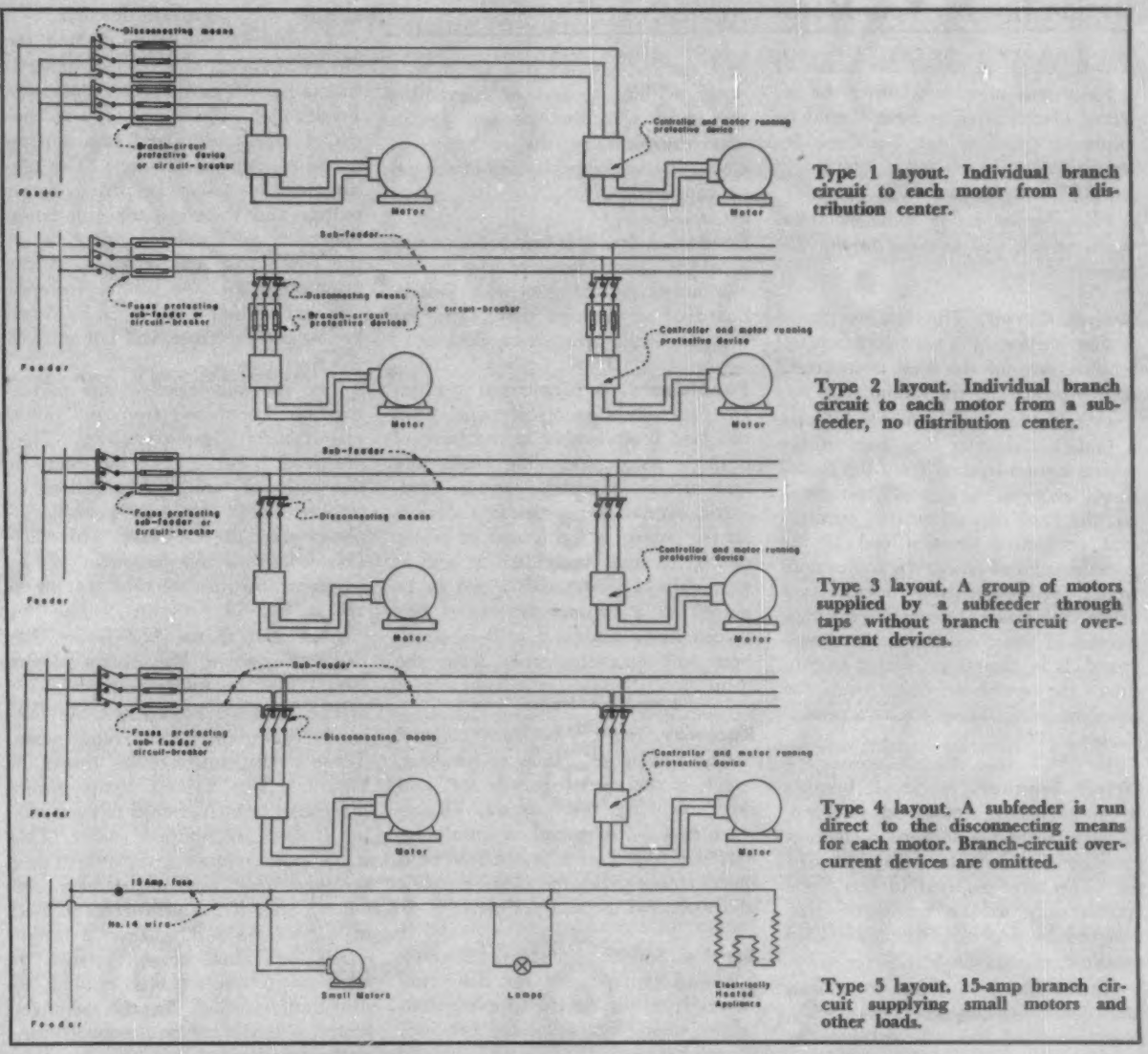
Disconnecting means
Branch-circuit protective device or circuit-breaker
Feeder
Motor
Controller and motor running protective device
Type 1 layout. Individual branch circuit to each motor from a distribution center.
Sub-feeder
Fuses protecting sub-feeder or circuit-breaker
Disconnecting means
Branch-circuit protective devices
or circuit-breaker
Controller and motor running protective device
Type 2 layout. Individual branch circuit to each motor from a subfeeder, no distribution center.
Type 3 layout. A group of motors supplied by a subfeeder through taps without branch circuit overcurrent devices.
Type 4 layout. A subfeeder is run direct to the disconnecting means for each motor. Branch-circuit overcurrent devices are omitted.
15 Amp. fuse
No. 14 wire
Small Motors
Lamps
Electrically Heated Appliance
Type 5 layout. 15-amp branch circuit supplying small motors and other loads.

FIGURE 1—Five circuit arrangements are covered by the National Electrical Code.

PART 1

Design Tips For Your Motor Circuits

A typical refinery unit's motor circuit system will be designed, step by step, citing the National Electrical Code rule that applies.

J. P. Chamberlain
Delta Refining Company
Memphis, Tenn.

ELECTRIC POWER is playing an ever increasing role in refinery power application. As electric power becomes more dependable, the need for steam driven stand-bys is being reduced. The plant engineer, therefore, is required to select more motors, motor starters, and circuit breakers than ever before. Yet, there seems to be some confusion in the minds of many engineers when it comes to doing this.

Presented here are a few rules and tables from the 1956 edition of the National Electrical Code. When properly applied they will enable the engineer to size the majority of motor starters, circuit breakers, and wire which he will encounter. No attempt

will be made to define the extent of a hazardous area or whether the selected electrical equipment should be explosion proof or not. For these determinations the reader is referred to the API Standard RP-500.

First, let us define some electrical terms which will be used in the discussion.

Branch Circuit. The branch circuit is that portion of a wiring system extending beyond the final overcurrent device protecting the circuit.

(When considering motor circuits, a branch circuit is that part of the wiring system leading from the feeder or subfeeder to the motor. Most motor circuits have two automatic, overcurrent protective devices, one at the panelboard and one at the motor controller. The overcurrent device (fuse or circuit breaker) protecting the conductors of the circuit is at the panelboard. It is, therefore, correct to consider the entire circuit from the panel-board to the motor as a branch circuit.)

Circuit Breaker. A circuit breaker is an enclosure designed to open, under abnormal conditions, a current-carrying circuit without injury to itself. The term as used in this Code applies only to the automatic type designed to trip on a predetermined overload of current.

(In the above definition, the abnormal conditions would consist of a heavy overload and sufficient capacity in the equipment supplying the circuit to maintain the system voltage under the overload.)

Controller. A controller is a device or group of devices which serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

Device. A device is a unit of an electrical system which is intended to carry but not consume electrical energy (Common examples of devices are switches, fuses, circuit breakers, controllers, receptacles and lampholders).

Explosion Proof. Explosion proof means enclosed in a case which is capable of withstanding an explosion of a specific gas or vapor which may occur within it, and of preventing the ignition of the specified gas or vapor surrounding the enclosure by sparks, flashes or explosions of the gas or vapor within.

Feeder. A feeder is any conductor of a wiring system between the service equipment or the generator switchboard of an isolated plant, and the branch circuit overcurrent device.

Panelboard. A panelboard is a single panel or a group of panel units designed for assembly in the form of a single panel; including buses, and with or without switches and/or automatic overcurrent protection devices for the control of light, heat, or power circuits of small individual as well as aggregate capacity; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front.

Raceway. A raceway is any channel for holding wires, cables or bus-bars, which is designed expressly for, and used solely for this purpose. (Raceways may be of metal or insulating material. The term includes rigid metal conduit, flexible metal conduit and electrical metallic tubing.)

Service. Service refers to the conductors and equipment for delivering energy from the electric supply system to the wiring system of the premises served.

[A service consists of two parts: (a) the service conductors (those wires from the supply poles or transformers to the first circuit breaker) and (b) The service equipment (metering equipment, wireways, and main circuit breakers located near the point of supply and intended to constitute the main control and means of cut offs).]

In this discussion, it is assumed that all of the power for the refinery is furnished through one set of transformers. This power is then sent through the service conductors metering equipment, service disconnect circuit breakers, feeder circuit breakers and finally through the motor branch circuits to the motor. Methods for sizing each of these items will be described. In addition, the code rule for each point will be cited.

To illustrate the design method, the electrical system of a typical refinery's Fractionation and Feed Preparation Feeder unit will be used. It will consist of nine motors and one welding machine, duplex recepticle. The motors, with one exception, drive process pumps and therefore may all be in operation at the same time. All of the equipment will be sized on the assumption that the welding recepticles will be used only during a down period and therefore, will not enter in the circuit sizing.

The size and speed of the motors may be determined from the pump manufacturer's pump curves. They are sized to either drive the pump at the designed pumping conditions or to drive the pump at the peak horsepower point on the curve. This decision is left to the judgment of the engineer who has selected the pump and motor.

After the motor horsepower has been ascertained, the design of the circuit may be undertaken.

The National Electrical Code covers five different circuit arrangements. These arrangements are shown in Figure 1. The Type 1 layout covers individual branch circuits to each motor from a distribution center. This is the most common arrangement and the one most used in refinery circuitry; and, is the arrangement used in our example. The Type 2 layout covers individual branch circuits to each motor from a subfeeder, with no distribution center. In this arrangement, a feeder or subfeeder is carried around a process unit, building or area and branch circuits are tapped-on at convenient points. This is the same as the Type 1 layout except that the branch circuit, overcurrent devices are mounted individually at the points where the taps are made instead of being grouped at one location. The Type 3 layout is used when a group of motors are supplied by a subfeeder through taps without branch circuit, overcurrent devices. This arrangement is seldom used in a modern oil refinery. The Type 4 layout is one in which a subfeeder is run directly to the disconnecting means for each motor. Branch circuit, overcurrent devices are omitted, as in the Type 3 Layout. The last layout is Type 5 in which a 15 or 20 amp. branch circuit feeds one or more small motors. This arrangement is fre-

"The first step in sizing the wire is to determine the current requirement of each motor. Contrary to many engineers' belief, the current rating stamped on the motor name plate is not used."

quently used where a fractional horsepower injection pump or fan motor operates from the refinery lighting circuit.

The first step in sizing the wire is to determine the current requirement of each motor. Contrary to many engineers' belief, the current rating stamped on the motor name plate is not used. The Code covering this reads as follows (Note for future reference the number refers to the section in the National Electrical Code):

"4309 Current-Carrying Capacities. Current-carrying capacities shall be determined as follows: (a) General Motor Applications. Except as noted in Paragraph b below, whenever the current rating of a motor is used to determine the current-carrying capacity of conductors, switches, branch-circuit overcurrent devices, etc., the values given in Table 21 to 24 of Chapter 10, including footnotes, shall be used in lieu of actual current rating marked on the motor nameplate. Motor running overcurrent protection shall be based on the motor nameplate current rating. If a motor is marked in amperes, but not horsepower, the horsepower rating shall be assumed to be that corresponding to the value given in Tables 21 to 24, prorated if necessary."[1]

Paragraph b referred to in section 4309 covers sealed refrigeration, compressor motors.

For convenience in calculating the current requirements for motors in the example, Table 1 indicates the full-load current for motor sizes from one half to 200 horsepower. Tabulated in Table 2 is the full load current of the 440 volt motors used in the example. In addition to the full load current tabulation, the ratings for 125 percent of the full load current have been tabulated. This was done in order to size the motor branch circuit wire; that is, to size the wire from the branch circuit protective device to the motor.

The National Code covering this section reads as follows:

"4312. Individual Motor. Branch-circuit conductors supplying an individual motor shall have a carrying capacity not less than 125 percent of the motor full load current rating; provided, that conductors for motors used for short-time, intermittent, periodic, or varying duty may have a carrying capacity not less than the percentage of the motor name-plate current rating as shown in the following tables, unless the authority enforcing the code grants special permission for conductors of smaller size."[1]

Since all of the motors, except one, drive process pumps, the latter part of the above code rule will be disregarded, and branch circuit conductors will be sized as though each motor operated 100 percent of the time.

Once the 125 percent rated current valve for each branch circuit is known, the next step is to select the wire size which will carry this current. This can readily be determined from Table 3 or Table 4. Table 3 shows the allowable current carrying capacity of insulated conductors in a raceway (rigid metal conduit). Table 4 shows the allowable current carrying capacity of insulated conductors in open air.

At this point, observe a word of caution. Many city and county electrical codes specify the current-carrying capacities of wires. If the motor being installed is in an area having such a ruling, the local code will govern. It is assumed that the example refinery is situated in a city having such an ordinance. Table 5 shows the allowable current carrying capacities of conductors in raceways for the City of Memphis, which will be used for the example.

From Table 5, the size of the

TABLE 1

Full-Load Current*—Three-Phase A.C. Motors

	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
H.P.	110V	220V	440V	550V	2300V	220V	440V	550V	2300V
½	4	2	1	.8					
¾	5.6	2.8	1.4	1.1					
1	7	3.5	1.8	1.4					
1½	10	5	2.5	2.0					
2	13	6.5	3.3	2.6					
3		9	4.5	4					
5		15	7.5	6					
7½		22	11	9					
10		27	14	11					
13		40	20	16					
20		52	26	21					
25		64	32	26	7	54	27	22	5.4
30		78	39	31	8.5	65	33	26	6.5
40		104	52	41	10.5	86	43	35	8
50		125	63	50	13	108	54	44	10
60		150	75	60	16	128	64	51	13
75		185	93	74	19	161	81	65	15
100		246	123	98	25	211	106	85	20
125		310	155	124	31	264	132	106	25
150		360	180	144	37		158	127	30
200		480	240	192	48		210	168	40

For full-load currents of 208 and 200 volt motors, increase the corresponding 220-volt motor full-load current by 6 and 10 percent, respectively.

* These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, in which case the nameplate current rating should be used.

† For 90 and 80 percent P. F. the above figures should be multiplied by 1.1 and 1.25 respectively.

Note: This table is a reproduction of Table 24 of the Chapter 10 in the National Electrical Code.

TABLE 2

Full Load and 125 Percent Full Load Current Ratings

Pump No.	H.P.	Current Rating From Table 1	125 Percent Current Ratings
P-301	100	123 Amps.	154 Amps.
P-302	40	52	65
P-201	50	63	79
P-203A	7.5	11	14
P-204	60	75	94
P-206	40	52	65
P-209	7.5	11	14
P-211	30	39	49
Air Comp.	5	7.5	10
Total	...	433.5	...

TABLE 3

Allowable Current-Carrying Capacities of Conductors in Amperes

Not More Than Three Conductors in Raceway or Cable
(Based on Room Temperature of 30 C. 86 F.)

Size AWG MCM	Rubber Type R Type RW Type RU (14—2) Thermo-plastic Type T (14—4/0) Type TW (14—4/0)	Rubber Type RH	Paper Thermo-plastic Asbestos Type TA Var-Cam Type V Asbestos Var-Cam Type AVB	Asbestos Var-Cam Type AVA Type AVL	Impreg-nated Asbestos Type AI (14—8) Type AIA	Asbestos Type A (14—8) Type AA
14	15	15	25	30	30	30
12	20	20	30	35	40	40
10	30	30	40	45	50	55
8	40	45	50	60	65	70
6	55	65	70	80	85	95
4	70	85	90	105	115	120
3	80	100	105	120	130	145
2	95	115	120	135	145	165
1	110	130	140	160	170	190
0	125	150	155	190	200	225
00	145	175	185	215	230	250
000	165	200	210	245	265	285
0000	195	230	235	275	310	340
250	215	255	270	315	335	...
300	240	285	300	345	380	...
350	260	310	325	390	420	...
400	280	335	360	420	450	...
500	320	380	405	470	500	...
600	355	420	455	525	545	...
700	385	460	490	560	600	...
750	400	475	500	580	620	...
800	410	490	515	600	640	...
900	435	520	555	...	...	...
1000	455	545	585	680	730	...
1250	495	590	645	...	...	...
1500	520	625	700	785	...	...
1750	545	650	735	...	...	...
2000	560	665	775	840	...	...

Correction Factor for Room Temperatures over 30 C. 86 F.

C.	F.						
40	104	.82	.88	.90	.94	.95	...
45	113	.71	.82	.85	.90	.92	...
50	122	.58	.75	.80	.87	.89	...
55	131	.41	.67	.74	.83	.86	...
60	140	...	.58	.67	.79	.83	.91
70	158	...	.35	.52	.71	.76	.87
75	167	...	...	.43	.66	.72	.86
80	176	...	...	.30	.61	.69	.84
90	194	...	...	...	.50	.61	.80
100	212	...	...	...	...	.51	.77
120	248	...	...	...	...	...	.69
140	284	...	...	...	...	...	.59

Note: This table is a reproduction of Table 1 of Chapter 10 in The National Electrical Code.

TABLE 4

Allowable Current-Carrying Capacities of Conductors in Amperes

Single Conductor in Free Air
(Based on Room Temperature of 30 C. 86 F.)

Size AWG MCM	Rubber Type R Type RW Type RU (14—2) Type T Type TW	Rubber Type RH	Thermo-plastic Asbestos Type TA Var-Cam Type V Asbestos Var-Cam Type AVB	Asbestos Var-Cam Type AVA Type AVL	Impreg-nated Type AI (14—8) Type AIA	Asbestos Type A (14—8) Type AA	Weather Proof Type WP Type SBW
14	20	20	30	40	40	45	30
12	25	25	40	50	50	55	40
10	40	40	55	65	70	75	55
8	55	65	70	85	90	100	70
6	80	95	100	120	125	135	100
4	105	125	135	160	170	180	130
3	120	145	155	180	195	210	150
2	140	170	180	210	225	240	175
1	165	195	210	245	265	280	205
0	195	230	245	285	305	325	235
00	225	265	285	330	355	370	275
000	260	310	330	385	410	430	320
0000	300	360	385	445	475	510	370
250	340	405	425	495	530	....	410
300	375	445	480	555	590	....	460
350	420	505	530	610	655	....	510
400	455	545	575	665	710	....	555
500	515	620	660	765	815	....	630
600	575	690	740	855	910	....	710
700	630	755	815	940	1005	....	780
750	655	785	845	980	1045	....	810
800	680	815	880	1020	1085	....	845
900	730	870	940	....	....	....	905
1000	780	935	1000	1165	1240	....	965
1250	890	1065	1130	....	....	....	....
1500	980	1175	1260	1450	....	....	1215
1750	1070	1280	1370	....	....	....	....
2000	1155	1385	1470	1715	....	....	1405

Correction Factor for Room Temperatures over 30 C. 86 F.

C.	F.							
40	104	.82	.88	.50	.94	.95	....	....
45	113	.71	.82	.85	.90	.92	....	....
50	122	.58	.75	.80	.87	.86	....	....
55	131	.41	.67	.74	.83	.86	....	....
60	140	....	.58	.67	.79	.83	.91	....
70	158	....	.35	.52	.71	.76	.87	....
75	167	....	....	.43	.66	.72	.86	....
80	176	....	....	.30	.61	.69	.84	....
90	194	....	....	....	.50	.61	.80	....
100	212	....	....	....	....	.51	.77	....
120	248	....	....	....	....	....	.69	....
140	284	....	....	....	....	....	.59	....

Note: This table is a reproduction of Table 2 of chapter 10 in the National Electrical code.

branch circuit wire for each of the motors is as follows:

P-301	3/0	
P-302	4	
P-201	2	
P-203A	14	use #12 instead
P-204	2	
P-206	4	
P-209	14	use #12 instead
P-211	6	
Air Comp.	14	use #12 instead

Note that in three instances, #14 conductors were suitable, but because of company policy, #12 conductors were selected. Number 14 wire is used only for control circuits in the process area.

Should any of the motors branch circuits be of any great length, the wire size of that branch should be checked for voltage drop. In this case, all of the motors are assumed to be within 50 feet of the panelboard and this is not necessary. Later in the example, the voltage drop for the feeder serving the motor branch circuits will be calculated.

After the conductors for the individual branch circuits are selected, the next step is to size the feeder conductors. The code covering this reads as follows:

"4314. Conductors Supplying Several Motors. Conductors, supplying two or more motors shall have a current-carrying capacity of not less than 125 percent of the full-load current rating of the highest rated motor in the group plus the sum of the full load current ratings of the

TABLE 5

City of Memphis

Current Carrying Capacities of Conductors in Raceways

Size AWG Conductor	Amperes	Size AWG Conductor	Amperes
14	15	350M	260
12	20	400M	280
10	30	500M	320
8	40	600M	355
6	55	700M	385
4	70	750M	400
2	95	800M	410
1	110	900M	435
0	125	1000M	455
00	145	1250M	495
000	165	1500M	520
0000	195	1750M	545
250M	215	2000M	560
300M	240	.....	...

"When designing your refinery unit's electrical system, make ample provision for future loads."

TABLE 6

Number of Conductors in Conduit or Tubing

Rubber Covered, Types RF-32, R, RH, RW and RU Thermoplastic, Types TF, T and TW—600 Volts One to Nine Conductors

Size AWG MCM	NUMBER OF CONDUCTORS IN ONE CONDUIT OR TUBING								
	1	2	3	4	5	6	7	8	9
18	½	½	½	½	½	½	½	¾	¾
16	½	½	½	½	½	½	¾	¾	¾
14	½	½	½	½	¾	¾	1	1	1
12	½	½	½	¾	¾	1	1	1	1¼
10	½	¾	¾	¾	1	1	1	1¼	1¼
8	½	¾	¾	1	1¼	1¼	1¼	1½	1½
6	½	1	1	1¼	1½	1½	2	2	2
4	½	1¼	*1¼	1½	1½	2	2	2	2½
3	¾	1¼	1¼	1½	2	2	2	2½	2½
2	¾	1¼	1¼	2	2	2	2½	2½	2½
1	¾	1½	1½	2	2½	2½	2½	3	3
0	1	1½	2	2	2½	2½	3	3	3
00	1	2	2	2½	2½	3	3	3	3½
000	1	2	2	2½	3	3	3	3½	3½
0000	1¼	2	2½	3	3	3	3½	3½	4
250	1¼	2½	2½	3	3	3½	4	4	4½
300	1¼	2½	2½	3	3½	4	4	4	4½
350	1½	3	3	3½	3½	4	4½	4½	5
400	1½	3	3	3½	4	4	4½	5	5
500	1½	3	3	3½	4	4½	5	5	6
600	2	3½	3½	4	4½	5	6	6	6
700	2	3½	3½	4½	5	5	6	6	...
750	2	3½	3½	4½	5	6	6	6	...
800	2	3½	4	4½	5	6	6	...	...
900	2	4	4	5	6	6	6	...	...
1000	2	4	4	5	6	6	...	...	...
1250	2½	4½	4½	6	6	...	...	...	...
1500	3	5	5	6	...	...	...	...	...
1750	3	5	6	6	...	...	...	...	...
2000	3	6	6	...	...	...	...	...	...

* Where a service run of conduit or electrical metallic tubing does not exceed 50 feet in length and does not contain more than the equivalent of two quarter bends from end to end two No. 4 insulated and one No. 4 bare conductors may be installed in 1-inch conduit or tubing.

Note: This table is a reproduction of Table 4 of Chapter 10 in the The National Electrical Code.

remainder of the motors in the group."[1]

The design load on the motor feeder, in the example, is the sum of the full load current ratings of the motors plus 25 percent of the largest motor, that is, 433.5 plus 30.8 = 464.5 amps. By referring to Table 5, we find that this load will require three 1250 MCM conductors having a current rating of 495 amps. per phase. By referring to Table 6 we see that 3-1250 MCM conductors will require a 4½ inch conduit. Because of physical limitations and the availability of the wire, we will pull two parallel conductors per phase. By again referring to Table 5, we find that 1-400 MCM conductor will carry 280 amps. which is over 50 percent of 464.3 amps, or 233 amps. From Table 6, we see that we could pull all six conductors in one 4 inch conduit. Again, because of physical limitations, our maximum size conduit is 3 inches. Had the physical limitations not excluded the use of the 4-inch conduit, the 6-400 MCM conductors in one conduit would have been unsatisfactory. The National Code provides that when the number of conductors in a raceway or cable is from 4 to 6, the allowable current carrying capacity of each conductor shall be 80 percent of the values in Table 3. If the number of conductors in a raceway or cable is from 7 to 9, the allowable current carrying capacity of each conductor shall be reduced to 70 percent of the value of Table 3. Using 6-400 MCM in one raceway, the allowable current per phase would have been: 2 × 280 × 80 percent = 448 amps. The design load is 464.3 amps. Therefore, 6 = 400 MCM in one conduit is too small. Six 400 MCM conductors in two conduits would have been satisfactory.

A 3 inch conduit is required for 3-400 MCM conductors as well as for 3-500 MCM conductors (Table 6). The cost between the two runs is only the difference in the price of the wire. Therefore, as we expect to add more load to this panel at a future date, we will install two parallel runs of 3 inch conduit, each containing 3-500 MCM conductors.

The two parallel runs of 500 MCM wire will have a current-carrying capacity of 320 amps per run or a total of 640 amps. This will then allow a future load of approximately 185.7 ampres.

The length of the feeder is assumed to be 165 feet. The voltage drop on this run should be checked to see that it is less than 3 percent of 440 V. or 13.2 volts.

$$\text{Voltage Drop} = \frac{24 \times D \times I}{\text{Circular Mills}}$$

D = the single distance in feet

I = Current in Amps.

$$\text{Voltage Drop} = \frac{24 \times 165 \times 433.5}{2 \times 500{,}000} = 1.72 \text{ volts}$$

Therefore, the feeder is adequate with regard to voltage drop.

TO BE CONTINUED

About the Author

J. P. Chamberlain is chief engineer for Delta Refining Company, Memphis, Tenn. In his present position he is in charge of design, maintenance, and construction. He graduated in 1947 from the University of Wisconsin with a B.S. degree in mechanical engineering. Prior to joining Delta he had ten years diversified petroleum refining experience with Standard Oil Company (Indiana), The Pure Oil Company, and Derby Oil Company. Chamberlain is a registered professional engineer in Texas, Kansas, and Tennessee.

Instrument Panels Made For Easier Operation

With the ever growing tendency to get and record more data about a process unit, here is a plea for simplified presentation in the control room.

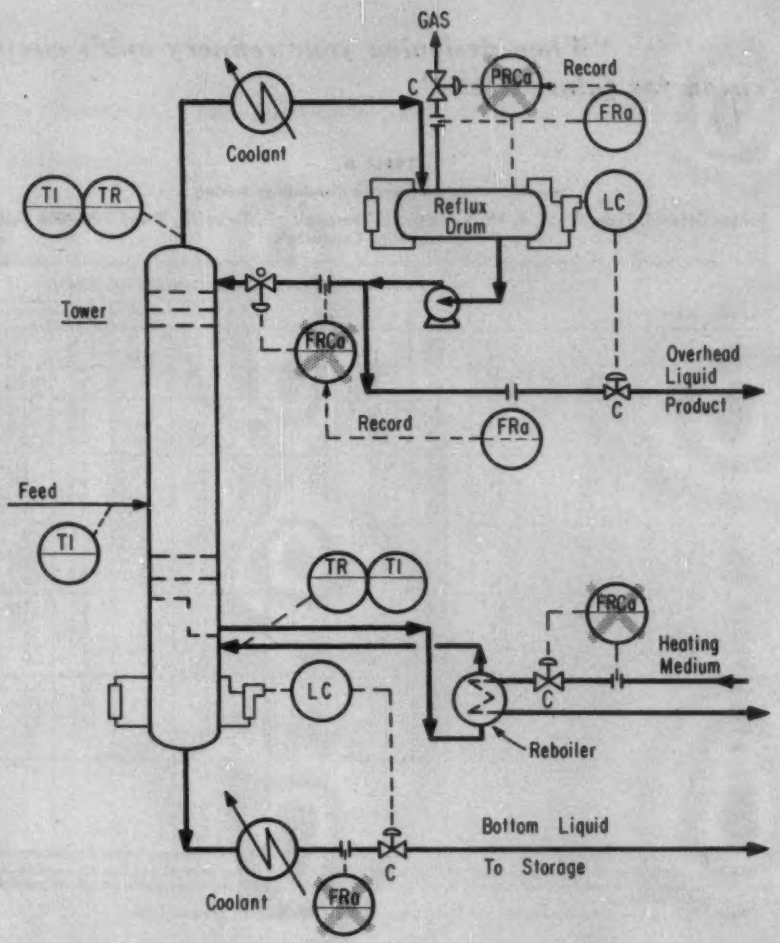

FIGURE 1—Many flow recorders may be eliminated from the control panel and the controller placed out in the unit.

J. D. Yanak
The M. W. Kellogg Company
New York

HOW OFTEN has it been remarked that the operator of a unit "runs his unit" by watching three, four, or five records (out of several dozen displayed)—many times these being temperatures on a multipoint recorder?

How often has a recorder demonstrated its uselessness, when inspection showed that its chart had not been changed for days—or weeks—with no harm to the operation?

These examples, which are all too common, signify that not enough care is taken in selecting records for display on the panel board. If one good operator can monitor a process with a minimum number of variables which he has found out for himself, a less capable operator can be taught the same technique or trained enough in process application to appreciate the value of the records he has.

In the process plant or refinery, there is an example of decision making that relies on rapid data accumulation which, in the management picture, is extremely important because of its basic influence on productivity and efficiency. With plant throughputs as large as they are now, faulty decisions can result in costly shutdown, loss of valuable on-stream time, or production of less valuable off spec. material. On the other hand, the operator's intelligent use of data available can increase operating efficiency, increase yields and extend periods between required maintenance shutdown. Obviously, the operator's decision making is a vital component of the over-all plant economy and any attempt to facilitate this function is worthwhile.

The ideal would be one ace operator making all operating decisions on the plant at one time; but consider the central control room of a typical integrated refinery. The trend toward the integrated refinery (i.e. each process unit feeding the next process unit with minimal intermediate storage) demands a central control room to monitor the over-all operation from

one vantage point. This means the graphic control panel (graphic to assist the monitoring function and as a training aid) is often 120 to 150 feet long and requires an inordinately great number of operators. Multiplying the number of operators in itself is costly. It also partially nullifies the advantages of centralized control because it leads to a confusion resulting from more people in the control room and it increases the hazards of communication between individuals monitoring related sections of plan.

This is a ready-made application for the data logger and scanner and as the reliability of this equipment is improved (as is happening now almost weekly), the answer to the operator-information problem will be more and more found here.

Another recourse is to judiciously re-evaluate the multiplicity of records and indications displayed on control room panels and consider the means of best utilizing the data recorded to achieve the most efficient control room. Control room efficiency can be achieved by reducing the span of control board monitored, providing the reduction does not impair the operator's ability to make those decisions vital to his function. Again control room efficiency can be improved by a data display that simplifies identification of data point with process by the operator. It would seem that this aim is worthwhile enough to justify added capital expenditure, if such is necessary.

First, the obvious way to reduce the span of the control panel is to minimize panel-mounted instruments. This may sound like a gross approach to the problem, but it should be borne in mind that a plenitude of data does not help the operator unless it is the specific information he needs for decision-making.

At the start it should be stated that only recording instruments or the recording parts of controllers should be omitted. It must be assumed that any controller or alarm placed on a panel is required—the controller to provide a necessary automatic action, the alarm to monitor a critical point. The controller may be blind or located locally with a local set point rather than on the panel, but these should be determined on their merits. Little can be gained by eliminating temperature indicator or recorder points, as these are ganged and take up little space. So the basic analysis starts with: "What records are found on the board and how do they help the operator?"

Data are needed by other refinery people besides the operator. True, many records are used mutually, but there are many that are of no use to the operator and only contribute to the excessive board size he has to survey. The result is that today all records relating to a plant or area are displayed in one location—a holdover from the days of large case instruments and one control room per process unit. These records can be separated by determining their ultimate users:

1. Management's needs are not for raw data but for data that have been worked up (correlated) by the subordinate functions. Therefore, control room raw data is not of direct concern.

2. The process Engineer's needs are the most demanding. He needs the most complete sets of records to work up heat and material balances, efficiencies and correlations. Naturally then, process engineer and operator will require some of the same data, but temperatures needed for heat balances, and temperatures and pressures needed for volume corrections would only be of use to the operator if coincidentally they were also operating variables. Usually product flows are of little use to the operator (telling him only a pump or control valve is functioning), but are surely essential for process analysis. Eliminating superfluous process data from the control room means that the process engineer's data needs, which of course are valid, must be met otherwise, and are best served by the automatic data logger which prints out on log sheets or tape periodically or on demand. Although a data logger is expensive, other groups in the plant can use it and the addition of the scanning function can help the operator immeasurably by warning him of the deviation of important variables from pre-set limits and so render him independent of certain board-mounted records or alarms.

3. For accounting, the product and yields group data needs are most important because they control the inventory of the plant and record the productivity of the plant. The source of these data are the feed, product, and utility meters which are usually located on the control room panel. Unfortunately, these records only tell the operator that his feed and product pumps are working and he has utilities. If this information is considered worthy of the operator's attention, he can get what he needs from appropriate alarms which take less space.

The records needed by the occuntants, together with their integrators, should be mounted away from the control room panel, although conceivably they could be ganged behind the board out of the operators way. When the computed functions of data loggers are dependable, this will be the logical way to record accounting data.

4. If instrument maintenance data needs are served by instrument records, a vicious cycle has been set up, because it would mean an instrument needed a record to monitor its own functioning. But this is not so. True, instrument settings are made most expeditiously with a record, but can also be done by watching an indicator. Where records are used to monitor the operation of pumps or compressors, this can also be done more directly with appropriate (pressure, flow or vibration) alarms. We do not believe maintenance requirements or desires should contribute to extending the size of the control panel.

Principles of Record Elimination. Records that will not be used should not be considered in the plant design stage, of course. Unfortunately, the low added cost of a record, especially when a controller for the variable is required, is apt to confound judgement. For a small price an additional plot of data is available which somebody *might* use. The small price is an illusion because increased panel length and increased building size are not insignificant cost increments. Besides hampering the operator, in the initial stages of start-up or operator break-in, the training problem is complicated because there are more data points to become acquainted with and learn to evaluate. This latter objection can be met in part by teaching the operator the logic of the process and instrumentation scheme, and this procedure should always be a part of operator training.

To take a positive approach, do not put records in the control room that

do not help the operator monitor his process. For those variables of secondary importance, retain the control of these variables, but eliminate the records or at least remove these records from the central control room.

To evaluate whether a record of a variable should be provided on the control panel for the operator's use, the following questions should be asked:

1. What does the record tell about changes occurring in the process? Does it reflect changes in feed composition, deterioration of catalyst, a runaway reaction, or build-up of impurities?

2. What does the record tell about changes occurring in the major equipment? Can it detect harmful fouling, tower flooding, or rapid coking? If these changes are slow, the records or indications should be located locally.

3. How often must an adjustment be made to the controller? If frequent adjustments are necessary (several times a shift), it might not be a good idea to provide a blind controller which must be adjusted outside the control room.

4. Is the record for use of someone other than the operator?

The use of these principles should be weighed by qualifications of personnel available and peculiarities of start-up and shutdown procedures. Recognition of these factors may require either more records or other considerations like an analog computer for training and extra manpower for start-up. Better to employ these ideas than to burden the permanent instrument installation to satisfy extraneous factors.

The fact of instrument component dependability should be emphasized to those in the refinery who determine which points are to be recorded. This may go far toward dispelling the attitude of "Well, a record doesn't cost much and it will let us know if anything goes wrong;" "anything" referring to a control instrument failure. At the same time, the advantage to the operator of keeping the control panel small and compact should be pointed out.

To accept the approach to records developed above may require a re-orientation of thinking that is pretty well set in some quarters, but the results are definitely worthwhile. The easing of the operator's work in itself is the most important result, since he will have more of an opportunity to analyze his data and make those changes which will contribute to efficient operation of the plant. In addition, reductions in capital costs of panel and building follow.

Beyond this, it is a necessary re-orientation for those refiners interested in installing data loggers. To date all process data loggers installations have had duplicate board-mounted recorders. The next step will be to eliminate as many of the board-mounted records as dependability of the data loggers permits and this means following the approach outlined above, to leave on the board necessary instruments as trend recorders or leave the operator those instruments he needs to run the plant if the data logger was out completely.

Light End Tower Example. It might be worthwhile to show this method in practice, so that the general procedure can be understood. The principles stated above are general, but by use of specific examples, the feasibility of the approach can be demonstrated.

Refer to Figure 1, which is the typical control instrumentation for light ends towers with gaseous feed streams (e.g. depropanizers, debutanizers, stabilizers, etc.) wherein the overhead liquid product is the most valuable stream. Not shown, is a flow record on the feed which would be a part of the instrumentation of the tower producing the feed.

The following simplifications in the instrumentation could be made (as crossed out in Figure 1):

1. The reflux flow record would be removed because it only tells that the pump and instrument are working.

2. The record of the pressure controller would be eliminated because the gas flow tells more. If more gas is made, the pressure controller would keep opening the valve to maintain the set pressure, but this would not show on the chart until the valve was wide open and out of control. However, the gas flow would immediately reflect any change in gas make calling for operator action. This gas flow record together with the overhead liquid product flow and the feed flow constitute a running material balance that the operator can be shown how to correlate.

3. These three flow records render the flow record of the bottom liquid superfluous because they constitute a material balance in themselves. The other function of the bottoms flow record which is to monitor the bottoms level controller, does not justify a record.

4. The record of the flow control on the heating medium is eliminated because it only monitors the controller.

The monitoring job will now be done by the temperature recorder point on the reboiler return line incidental to its main function of giving a rough record of bottom composition. Similarly, the temperature record of the vapor out of the tower top gives an indication of top composition when correlated with the pressure held.

Changes to set points of the three controllers whose records have been eliminated will not be made frequently so these controllers can be placed out in the unit and the operator can instruct the outside man to make adjustments when necessary.

As a result of this analysis, of 6 records (really 4 instruments because 2 records are combined), 4 are eliminated. The two flow records remaining could be combined on a two pen-two color chart because they are related flows. In addition, there are 2 temperature points on the multipoint recorder (overhead vapor and reboiler vapor) and a temperature indication on the feed, in all 5 pieces of data (6 with the feed flow) immediately available to the operator at the control panel for his control of this tower.

A reduction in instrument panel space of about one third to one half has been achieved by this analysis, assuming an 8 point panel mounted temperature recorder.

Vacuum Tower Example. Pursuing this type of analysis, examine the vacuum tower instrumented in Figure 2. All reflux and product flows (5) are eliminated from the main control panel because they are all set to hold flows dictated by laboratory results. Hence, they will be changed infrequently. The five flows (including 3 controlled flows) should best be located on a sub-panel outside at the base of the tower.

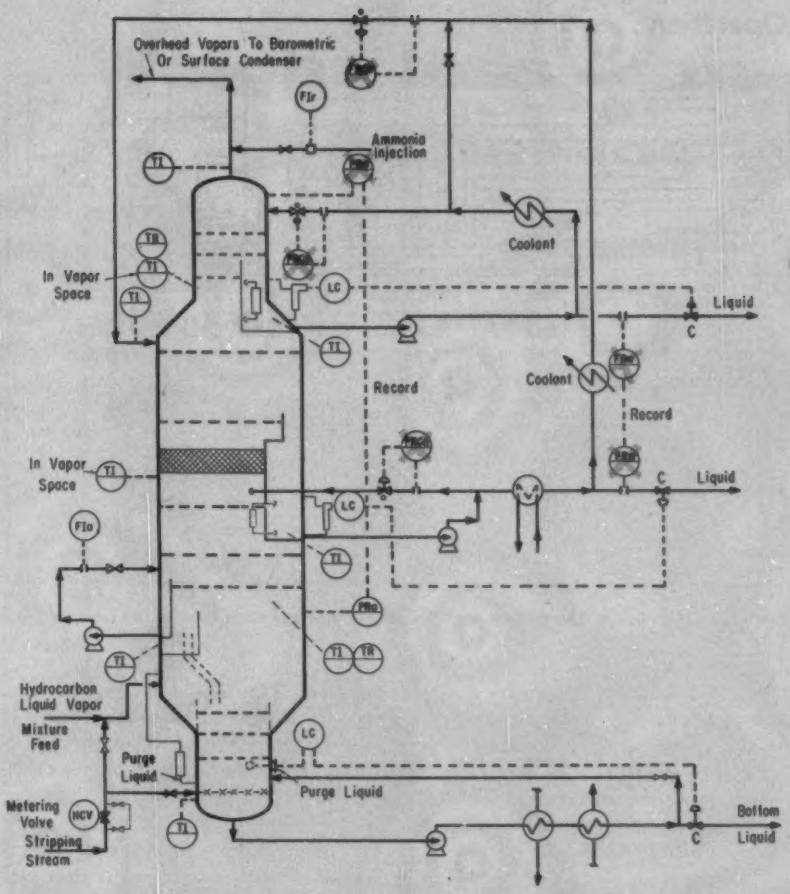

FIGURE 2—Some flows are set on the basis of laboratory results. Since these laboratory determinations usually have a long delay, the corresponding flows need not be placed on the instrument panel.

Although the pressure recorder at the top of the tower is eliminated, it could have been retained as a second pen on the pressure recorder. The deletion was made to indicate that it only serves to indicate pressure drop through the tower which build-up would be a progressive thing. The operator is left with 10 data items, the flash zone pressure and nine temperatures, which together with the periodic laboratory analyses tell him all he needs to know about the vacuum tower.

The analysis of the vacuum tower records has resulted in the elimination of four out of five instrument recorders (exclusive of the temperature recorder points). The operator is still left with enough information to follow the operation of the tower and to instruct the outside operator what changes to make in reflux rate settings.

A boon to the vacuum tower operator (or crude fractionator operator) would be continuously recorded product analyses (tests) available in the control room, so making him independent of the control laboratory and free of the normal delay between sending a laboratory sample and getting back a test result. Such instruments are in the offing and will be available in a complete line before long. Adding such equipment would have the effect of increasing panel board size, because not only would these "tester records" require space, but those controls needed to be reset to give the required analysis or test would have to have their controls on the panels to enable the operator "to close the loop." Here the additional board space required by continuous testers would seem justified in enabling the operator to correct for minor product quality deviations as they occur, and so operate the tower at its maximum efficiency.

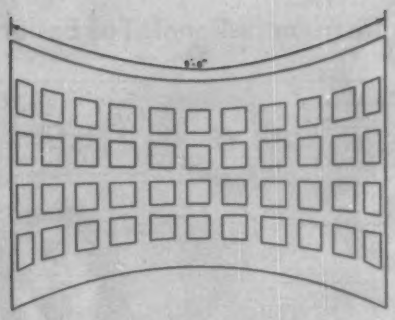

FIGURE 3—A display of instruments on a bare panel board may be confusing.

Frieze Type of Graphic Panel. The discussion and examples of instrument record simplification have proven that the number of recorder instruments can be reduced without penalizing the operator.

Now the problem should be approached of how to display the records left for maximum advantage to the operator. Just placing the instruments on a bare panel without pictorial representation would require one foot per instrument for large case instruments (two high) to one foot for six instruments for miniatures. This latter arrangement would enable an operator to monitor a large unit seated at a console, if the panel face was in a semi-circle. Figure 3 shows that this would be rather confusing.

The advantages of a graphic panel seem too worthwhile to discard at this time. To recapitulate these advantages:

1. Aids training of new operators.

2. Assists the operator in orienting his data with the overall plant (e.g. to avoid the confusion implicit in Figure 3).

3. In multi-unit plants, assists coordination of information between separate process units.

4. Adds aesthetic value to the control room.

The common type of graphic panel with the miniature instruments inset in the pictorial representation averages 1.5 to 1.7 instruments per foot. This is little better than the large case instrument on standard panel (1.0 instrument per foot) in over-all panel length and so shows little advantage to the panel size of reduced size of miniature instruments.

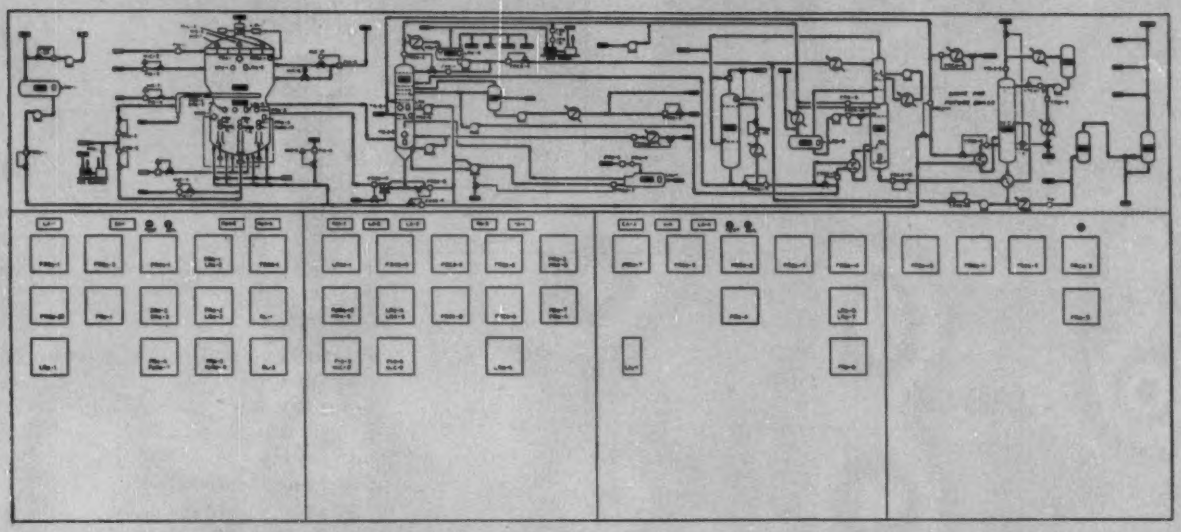

FIGURE 4—The instruments are placed in ranks and rows below the picture with an effort to locate each instrument near its place in the process scheme.

A scheme that uses the small size of the miniature and provides the operator with the facility of rapid correlation of data with position in process is shown in Figure 4. This scheme has been advocated before and is illustrated in a current instrument catalog, so is not original. However, it has never been named, so we shall refer to it as a "frieze panel" because this describes its continuous picture around the top of the panel. The instruments are placed in ranks and rows below the picture with an effort being made to locate the instrument approximately in the elevation of the point concerned. A deviation from this to within a man's body width is tolerated.

The following consideration on instrument placement in the frieze panel will give maximum utilization of board space with due allowance for the operator's requirements:

1. Do not exceed four high (preferably not more than three) instruments.

2. Where at all feasible, have the more important records (i.e. those on controllers) in the top two rows at eye-level.

3. Combine records which are related in some logical manner, such as cascaded controllers.

4. Keep all instruments for one item of process equipment together, i.e. do not interpose instruments from *another* tower, vessel or compressor.

5. Have cross identification (symbols) between instruments and the process positions on the pictures, preferably color-coded.

6. Place temperature indicators and multi-point recorders on console desks, located to permit the seated operator to monitor the panel.

7. Alarms should be placed directly below the picture.

As in a common graphic panel, the length of the frieze panel is determined by the relative size and density of the process equipment in the picture. Instrument density will vary from 3.0 to 4.5 instruments/foot of panel depending on the process illustrated.

The combination of the frieze panel with recorders selected for the operator's use according to the principles enunciated above offers a system of data display and utilization that will enable the operator to perform his duties efficiently and expeditiously and perhaps leave him time to analyze his data and prepare rule of thumb correlations as guides to making decisions. This will not happen automatically as a result of arranging mechanical equipment. The operators must be informed of the reasons for the arrangement, must be convinced of its benefits and perhaps even instructed in the principles of process design and automatic control, the better to understand the full import of the data points provided for their service. The time expended in these endeavors should be amply repaid in the results accruing from thoughtful plant operation—increased productivity, better product and reduced maintenance.

Further, these considerations will permit better integration of complex data systems (loggers, scanners or computers) into the control room, and so help toward the eventual goal of completely automatic, self-correcting plants. ##

About the Author

Joseph D. Yanak is an instrument division engineer for The M. W. Kellogg Co., New York, where he supervises the analytical and production sections of the instrument division. Yanak received his B.S. degree in 1939 from Lafayette College and his M.S. degree in 1942 from Brooklyn Polytechnic Institute, both in chemical engineering. With the exception of three years with the Air Force, Yanak has been with Kellogg continually since 1942 where he has held many positions of responsibility.

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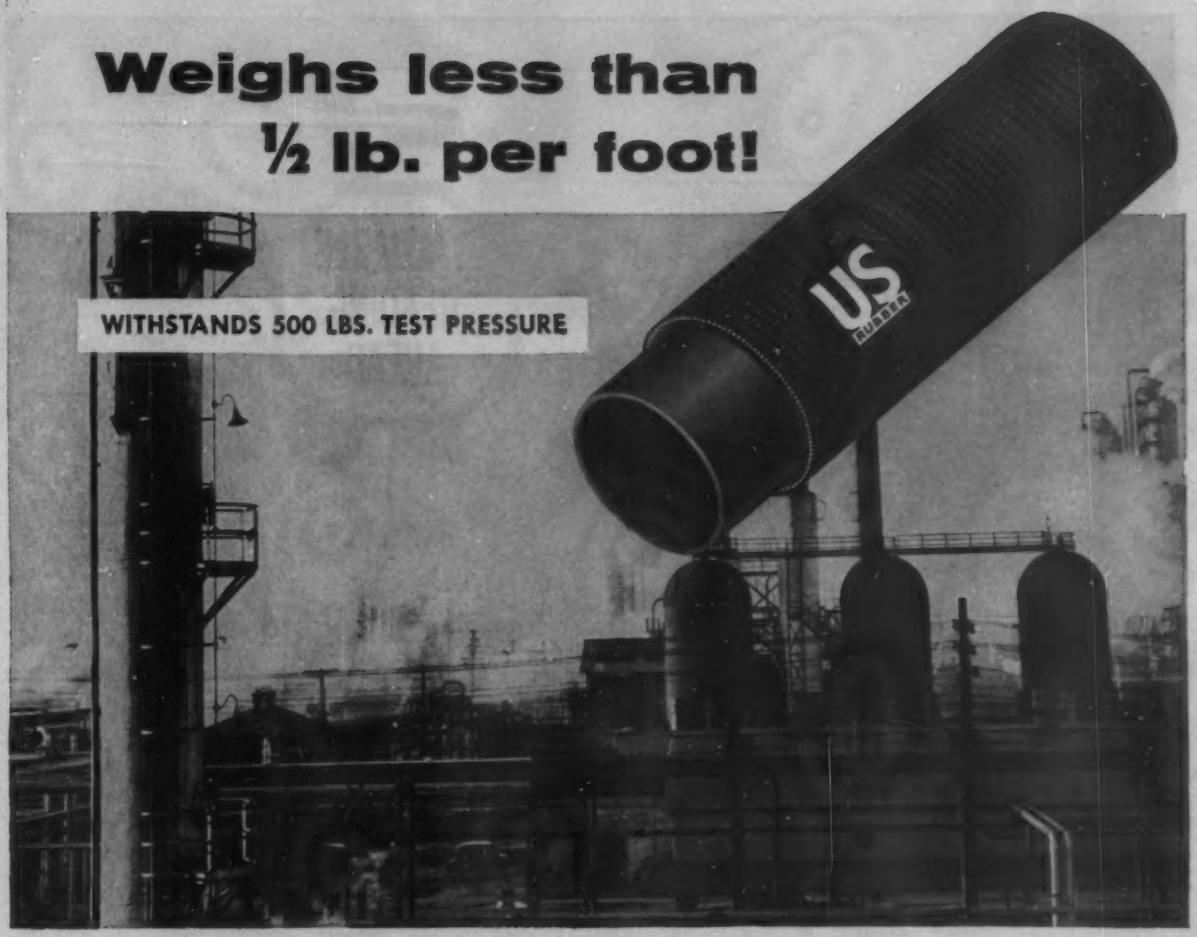

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Ever wonder what's happened to some of your friends and acquaintances that you haven't heard from in a long time? Well, if they're in the refining-petrochemical-gasoline industry you'll read about them sooner or later in "What's Happening Among Men in the Industry." Here's your surest-fire method for keeping up with personnel changes.

Keep Going to Page 306

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You'll want to read the review of the new book "Applied Statistics For Engineers." Statistical problems are given to enable the reader to apply statistical analysis to engineering data. You can learn all about it if you . . .

Keep Going to Page 254

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You won't have to wonder after you've read "What's Happening in the Industry," because then you'll know. Here's a monthly section that presents all the information on the highlights of industry happenings. It's there for the reading, so . . .

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Yes, times do change—and that's why you should read "Changing Times," the fast moving account of those items that made the news last month. It's just what's needed by busy industry men who want to get the news in a hurry. See for yourself!

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The answer to this question is ready and waiting for you in this month's section of "Who's Building." There are dozens of construction items presented in capsule form so that you can get the maximum information in the shortest time. There is also an interesting lead story that should be of special interest.

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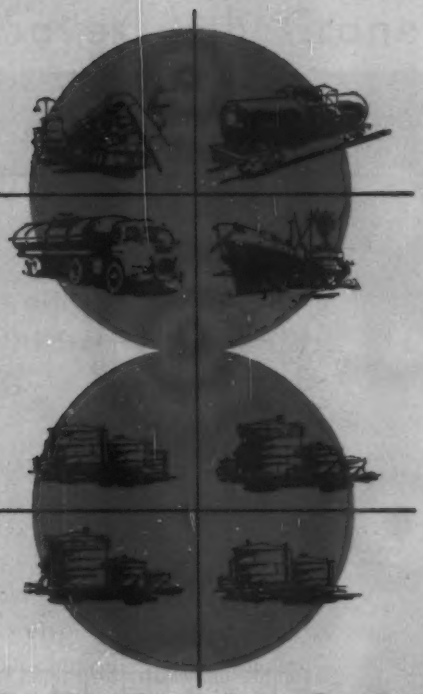
When, Where and What

For an easy-to-read tabulation of what's coming up in the associations and societies that are of most interest to you, PETROLEUM REFINER's "Meetings Calendar" is a "reading must." Important events are slated for the near future so . . .

Keep Going to Page 304



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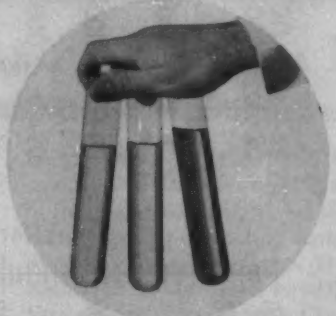

Fuel oil at *left* is fresh from refinery, bright and clear. *Center*, Nalco-treated oil is bright and sludge-free after four months. *Right*, untreated sample in four months time has darkened considerably, already begun to sludge.

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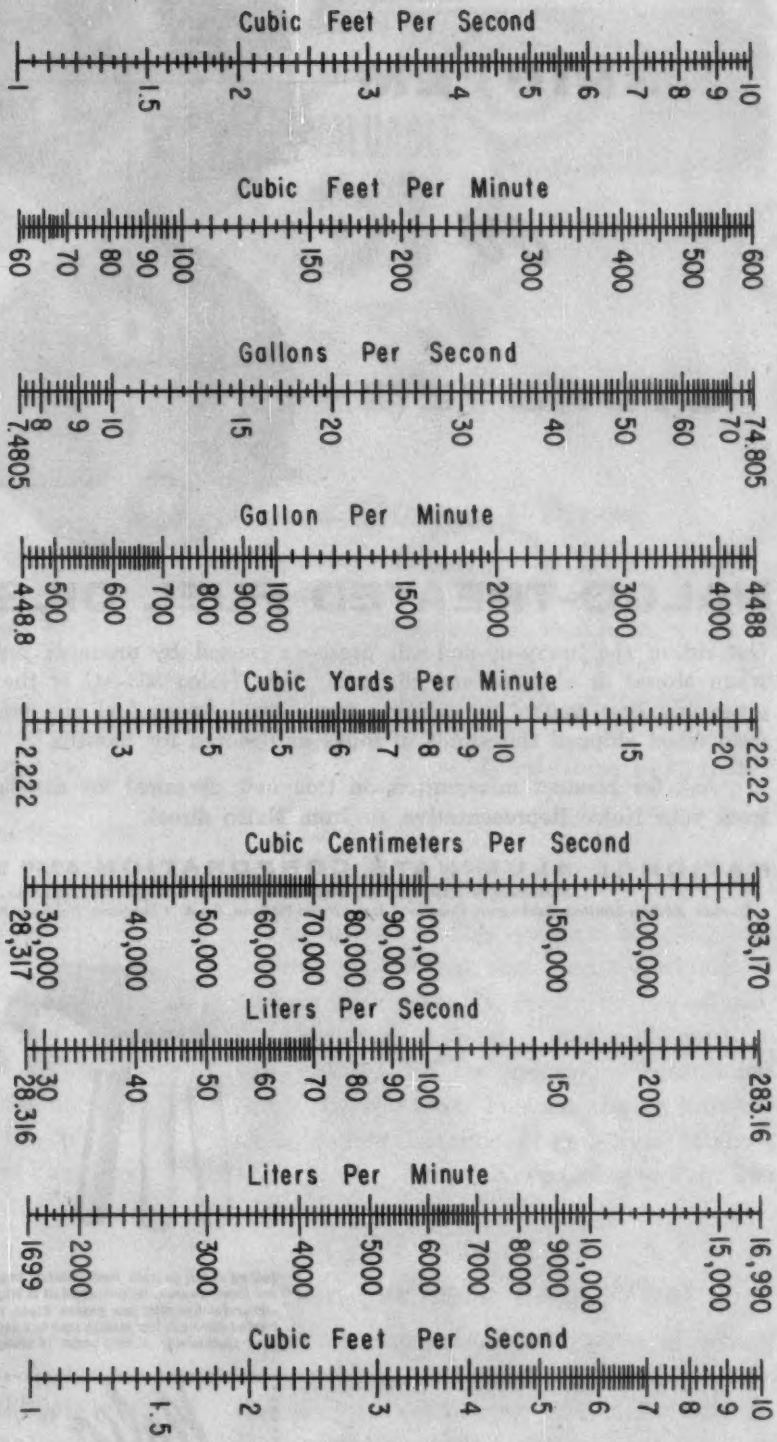
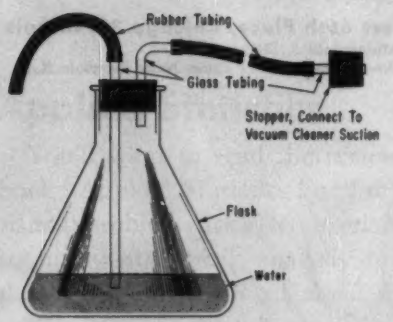
How To Do It

Try This Handy Flow Conversion Chart

This line chart provides an easy method for converting units of volume flow. Simply draw a line perpendicular to the scale lines through a known flow of value and read the equivalent value on any of the other scales.

Idea submitted by:
Marvin H. Green,
Philadelphia



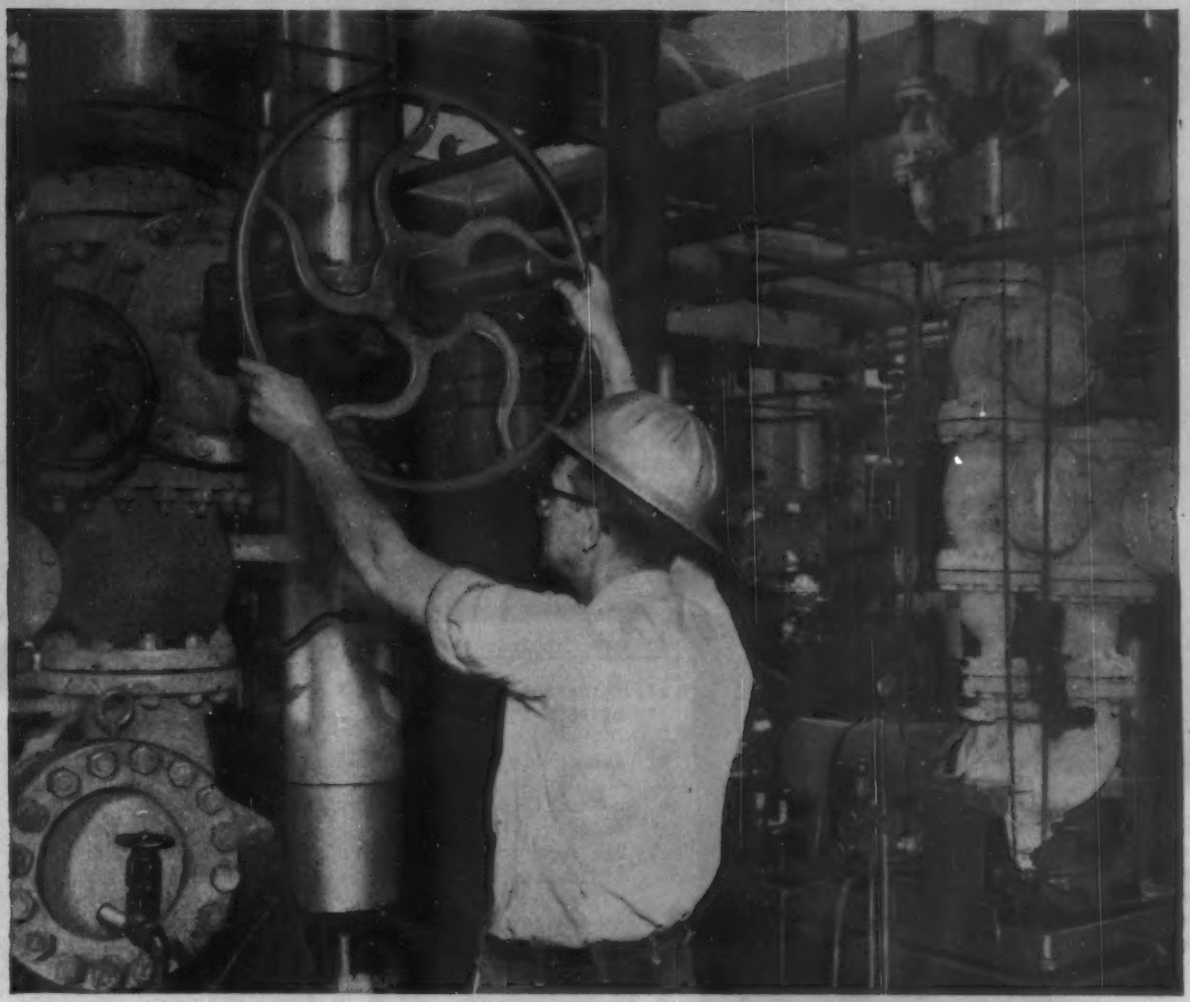


Pickup Loose Mercury With Flask and Vacuum Cleaner

Having trouble picking-up that mercury you spilled? It's a cinch to recover loose mercury with an ordinary vacuum cleaner but the trouble is in recovering the mercury.

By employing the use of an ordinary laboratory flask, three pieces of glass tubing, two rubber hoses and a couple of stoppers, a vacuum cleaner attachment can be made that will pick

Another Refinery Saves with Crane Steel Valves



14 years on 680° F. bottoms handling ... still no repairs on these valves

These 300-pound Crane steel gates and checks were installed in The Cities Service Refinery Corporation at Lake Charles, Louisiana in 1943.

Installed in the "A" topping unit, on discharge line from bottoms pump, they're still leak-free . . . show no sign of seat damage.

For 14 years these valves have handled this tough 680° F. service with no more attention than routine maintenance at turnarounds. Once-a-week operation at this high temperature hasn't affected their original smooth and accurate seating action.

In Crane Exelloy, these valves have a highly developed seating material for handling hot oil and oil vapor. It has excellent resistance to corrosion, wear and temperature effects. Teamed with Crane steel castings, it assures durable valve service on recommended applications.

Get complete facts on Crane steel valves with Exelloy trim from your Crane Representative, or write to address below.

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rigid specifications

Tension tests are required to be made at room temperatures and at 670° F. The following minimum physical properties shall be met:

At Room Temperature:

TS	YS	EL	RA	CHARPY V-NOTCH
70,000	30,000	45	50	50

At 670° F. the minimum tensile strength shall be 51,000 p.s.i. and the minimum yield strength 18,300 p.s.i.

Rejection

Each casting that develops unacceptable defects during shop working or fails to conform to all of the requirements of these specifications shall be rejected. No repair by welding or other means will be permitted.

Radiographic Inspection

(a) Paragraph S5 (a) of the Supplementary requirements of ASTM-A 362-52T.

(b) All castings shall be radiographed 100% and shall conform to ASTM-E7 1-52, Class 2 quality, except as modified by these specifications.

(c) The manufacturer shall establish a positive system of identification of the X-ray plates which shall be subject to approval by the inspector. This system shall guarantee complete coverage by radiographing and provide for positive identification between the plate and the subject.

All cast pipe shall be hydrostatically tested to 5,900 p.s.i. and held at that pressure for 20 minutes with zero pipe leakage. Each length of pipe shall be hydrostatically tested at the manufacturer's plant.

Inspection of Penetrants

All castings shall be subjected to inspection by fluorescent penetrants or penetrating dyes both inside and out. All cracks, porosity, or flaws revealed as a result of the Dye Penetrant Test shall be due cause for rejection of the casting.

The 304L stainless steel shall conform to the following ladle analysis:

Carbon	.03 max.		
Manganese	1.50% max.		
Phosphorous	.03% max.		
Sulphur	.03% max.		
Silicon	2.00% max.		
Chromium	18.00	-	21.00%
Nickel	8.00	-	11.00%

Pipe: All pipe of the following sizes shall be centrifugally cast stainless steel as per ASTM-A 362-52T, except as modified by these specifications:

16" - Sch. #160
12" - Sch. #160
10" - Sch. #160
8" - Sch. #140

All pipe shall be machine finished to 125 micro-inch interior and exterior.

for nuclear piping met by U.S. PIPE metal mold process

Centrifugally Cast Stainless Steel Solves Many Piping Problems

Combinations of temperatures, pressures and corrosive conditions never encountered before: these are among the piping problems that must be overcome by the men who design the nation's nuclear power installations.

Stainless steel centrifugally cast pipe provides many of the answers. Study the specifications at the left . . . specifications demanded of stainless steel pipe on a recent job for Paul Hardeman, Inc., Los Angeles, California. This pipe is being used for heavy duty, high pressure, elevated temperature service in the primary piping system of the SPERT-III Reactor at the U. S. Atomic Energy Commission's National Reactor Testing Station near Idaho Falls, Idaho. The Stearns-Roger Mfg. Company, Denver, Colorado, is the architect-engineer on this project. A complete tabulation of the actual test data obtained on this pipe and to this specification is available upon request.

U. S. Pipe is headquarters for metal mold centrifugally cast alloy and stainless steel pressure pipe over a wide range of special and standard analyses—in large and small quantities—and to individual specifications.

If piping of the type described above is the bottleneck in your nuclear power planning, write and outline the problem.

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Outside Diameter—6" to 50"

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- Eliminates Calculations! Automatically extracts square root — shows totals in desired units.
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Now you can integrate the flow of all process fluids or plant services *continuously* . . . with new accuracy . . . complete safety! The unique new, all-pneumatic Foxboro Flyball Integrator completely eliminates intermittent counting and fire hazard. Its simple, force-balance operation utilizes the 3-15 psi air signal from any differential-pressure flow transmitter. This signal is *continuously* balanced against the "flyball" force of the instrument's pneumatically-driven turbine. The square root function is automatically extracted . . . you read flow totals *directly*.

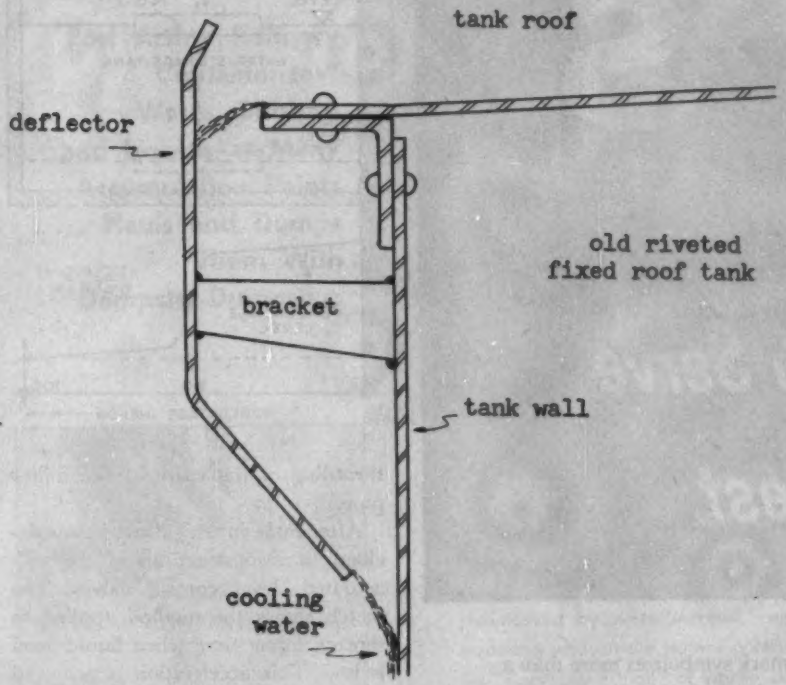
The Flyball Integrator mounts at the point of measurement or on a panel hundreds of feet away. Response and accuracy are completely unaffected by ambient temperature changes or pressure changes in turbine air supply. Ideal solution to all plant fluids accounting and in-process inventory checking. Write for complete details. The Foxboro Company, 743 Norfolk St., Foxboro, Mass.

FIRST IN FLOW

up the spilled mercury and reclaim it for further use.

The free stopper is attached to the vacuum cleaner and the mercury is drawn into the flask through the pickup hose. The purpose of the water is to prevent the possibility of mercury entering the vacuum cleaner after it splatters on the bottom of the flask.

Idea submitted by:
L. J. Theriot, Ethyl Corp.
Pasadena, Texas



Simple Deflector Ring Cools Tank Shell

The installation of permanent water spray system on a fixed roof storage tank has long been recognized as good practice for fire protection and evaporation control.

The roof edge of a cone roof storage tank usually extends from the tank wall because of the angle ring connecting the roof and wall. Therefore, water applied to the roof cannot wet the tank wall and reduce its surface temperature.

The Chinese Petroleum Corp.'s Kaohsiung refinery remedied this defect on its five 80,000 bbl. crude storage tanks by installing a deflector ring on each tank as shown in the illustration.

The deflector ring is made from three-sixteenths steel plate by cutting and bending to shape. It is supported by welding brackets, spaced several feet on center, to the deflector ring and the tank wall.

The direction of the cooling water run-off is thereby changed and the tank is uniformly cooled.

Idea submitted by:
Tzen-Yung Yang,
Kaohsiung, Taiwan

Cam Controls Float Valve

In a plant, a number of liquid inflows were controlled by conventional types of float valves. The disadvantage of the ordinary lever-arm, float valve is that filling time is usually very long. This is caused by prolonged inflow-

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GLAZED TILE
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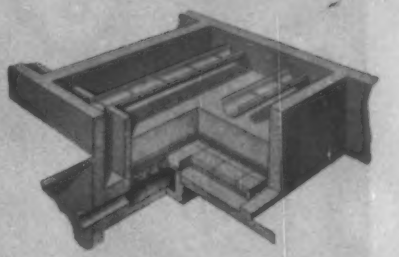
Successfully meet
all underdrain
requirements



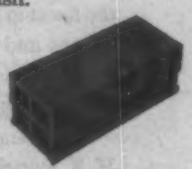
Filter unit showing Leopold Filter Bottom and Leopold Fiberglass-Reinforced Plastic Wash Troughs

Performance Proved in
over 375 plants with a
daily capacity of more than
2¾ billion gallons!

In this design, laterals and distributing blocks form a permanent unit that assures equal filtration and uniform wash distribution with low loss of head. Made of de-aired fire clay—vitrified and salt glazed—the blocks can't corrode, won't absorb water, are acid and alkali resistant, and are not subject to tuberculation.

In addition, the Leopold Filter Bottom needs only a shallow depth of small-sized filter gravel, does not require supporting concrete structures, and is the only design providing a fixed and controlled secondary backwash.

Literature and Complete Details Furnished on Request!



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For almost a century the Cleveland brand has marked industry's best automotive and industrial hardware and commercial forgings and die casting.

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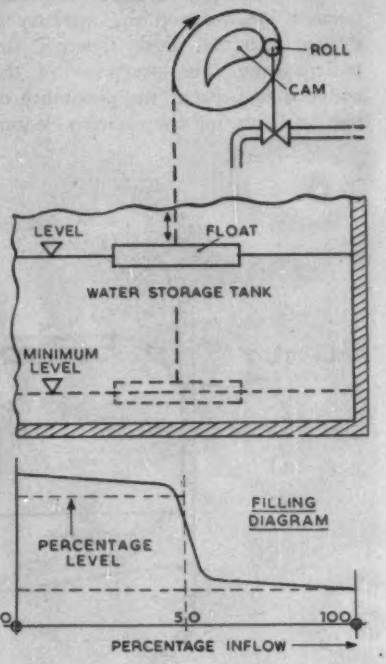
How to Do It . . .



throttling of the valve in the inflow pipe.

After some investigations it was decided to reconstruct all of the self-actuated, level control valves. The sketch shows the method applied to shorten filling time when liquid level is low. This acceleration is achieved by using a shaped cam which keeps the inflow control valve open most of the time, starting throttling action only near the desired liquid level. The curve in the lower part of the sketch indicates the result from reconstruction.

Such quick-filling liquid level control equipment can be made from suitable lever-arm valves by fixing a cam attachment, as shown. A roll fitted at the end of the lever arm glides on the cam surface.

YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

The TEXAS COMPANY "CONTAINERIZES" Waste as It Accumulates

Port Arthur Refinery "Containerizes" Waste, Rubbish and Liquids at Many Accumulation Points . . . Hauls and Dumps Them With Dempster-Dumpsters

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Waste disposal and plant cleanliness can no longer be efficiently maintained by wheelbarrows, cans, carts, or bins. Shoveling, re-handling and on-site dumping have been replaced in leading plants by "Containerization" of waste as it accumulates. By placing clean, big-capacity Dempster-Dumpster containers at accumulation points, you can save thousands of dollars annually and enjoy improved plant cleanliness.

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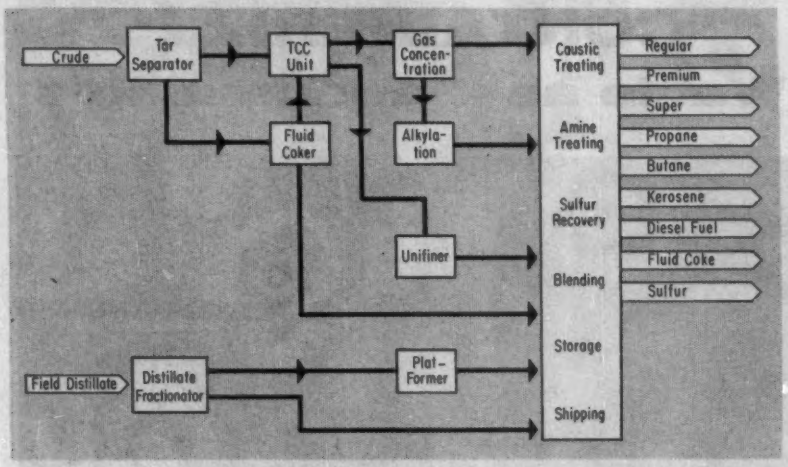

Pontiac Eastern Purvis Refinery Simplified Flow Chart

Pontiac Eastern Up With Purvis Plant

Alkylation, reforming, and hydrogen treating are part of new refinery.

PONTIAC EASTERN CORP'S Black Creek refinery has gone on stream near Purvis, Miss. It is located on a 2,000-acre tract on the banks of Black Creek in Lamar County, three miles north of Purvis.

The refinery consists of units for electric desalting, Thermofor catalytic cracking, fluid coking, gas recovery, sulfuric acid alkylation, unifining and platforming.

There are two major parallel flow patterns in the refinery; one is the crude oil stream and the other is the field distillate. The field distillate is separated by fractionation into four streams consisting of straight run gasoline, for blending; straight run naphtha, for platformer charge; kerosine as a final product and for blending into diesel fuel; and bottoms, which are added to the crude oil charge.

Mississippi crude oil and distillate is put into the plant at the rate of 14,500 bpd.

Crude oil is supplied by Gulf Oil Corp. from South Mississippi oil fields. These crudes are heavy and viscous and previously their sale was limited to the low value fuel oil and asphalt markets. The production of high quality lighter products from this crude was impractical and economically unsound prior to the very recent development of new refining processes and techniques incorporated in the new refinery.

Processing of Oil. Crude is separated into two streams by flash vaporization in the tar separator. The lighter overhead material, in vapor form, is charged to the thermofor catalytic cracking unit and the heavier bottoms are charged in liquid form to the fluid coker. These two units, using a combination of heat and catalytic action, crack or break down a large percentage of the medium and heavy hydrocarbons to the lighter gasoline range material.

There is a maximum production of

The new Mississippi refinery charges crude oil and field distillate.

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gasoline, a minimum amount of heavy fuel oil which the refinery utilizes for the production of steam, and 200 tons per day of coke, which is easily handled due to its fluidized state.

The gas concentration unit separates and concentrates the various liquid and gas hydrocarbon streams by means of absorption and fractionation processes. Its products are: a gas stream containing ethane and lighter gases which is further treated and then used as refinery fuel; cracked gasoline; and the propanes and butanes which are further processed in the alkylation unit.

A light cycle oil stream from the TCC unit is charged to the unifier. The treating area contains equipment for caustic treating to neutralize and remove traces of undesirable compounds, and the amine treater which removes hydrogen sulfide from the unifiner gas, gas plant gas and the alkylation feed.

Hydrogen sulfide from the amine solution is burned to form liquid elemental sulfur. Its design capacity is 27 tons of sulfur. A central control house is designed around a 108 foot long graphic panel from which the major process units are operated.

Products and Disposition. The refinery produces a variety of products, some being utilized in the operation of the plant itself and some marketed.

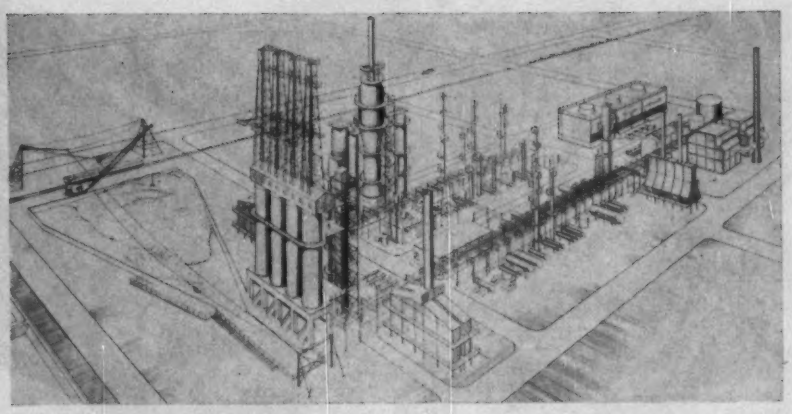
Gasoline is the principal product of the refinery, accounting for 85 percent of the plant's liquid product.

In addition, the refinery is capable of producing even higher-rated gasolines in anticipation of further improvements in automotive engines.

The yield of the plant will be one barrel of gasoline for each 1.35 barrels of raw materials. This is an extremely high gasoline yield considering the fact that 70 percent of the crude input at the plant is a sour viscous crude oil which contains less than one half of one percent natural gasoline.

The plant is designed to produce 11,500 barrels of automotive gasoline daily. It will also produce kerosine, diesel fuel, coke, and sulfur.

Fluor's Mid-Continent division, of Houston handled the project, the largest single installation completed by the division to date.



Distillation, coking and catalytic cracking to be added to Argentine plant.

Argentina's Lujan de Cuyo Plant to Expand

The Argentine government has approved a contract with The M. W. Kellogg Co., for the expansion of an oil refinery at Lujan de Cuyo, Argentina. The company will be responsible for process engineering, design engineering, procurement and construction for the new project. Expansion will consist of a 28,000 bpsd crude distillation unit, a 18,500 bpsd delayed coker and an 11,000 bpsd Orthoflow catalytic cracker and gas recovery unit. The offsite facilities will include a utility plant consisting of steam generation, boiler feedwater treating, compressed air, and dual fuel oil and fuel gas systems. Crude and intermediate product systems will include crude tankage and crude transfer lines and pumps.

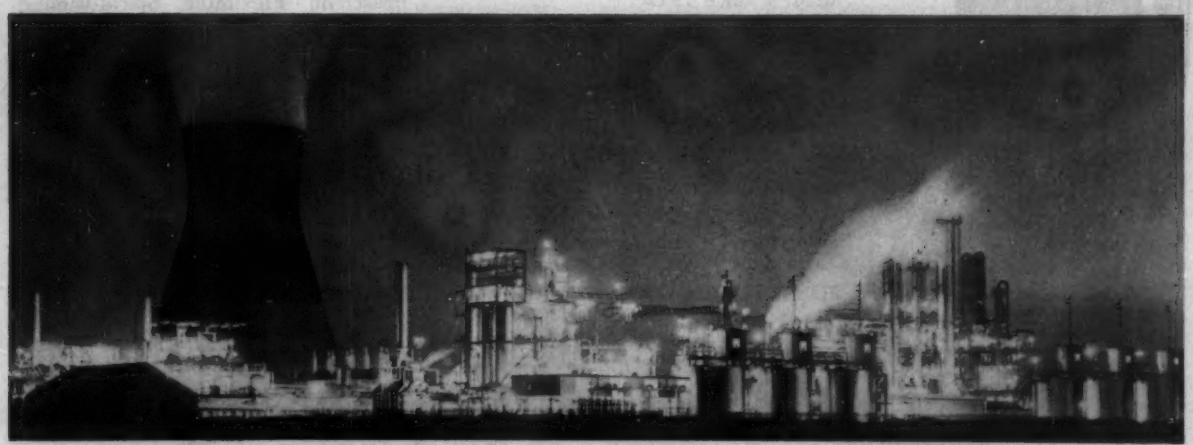
Auxiliary utility systems will consist of cooling water, steam, air and fuel distribution systems; blowdown and flare, fire fighting and electrical distribution systems.

Feedstocks for the new installation will be Barrancas crude, a waxy, low sulfur content crude produced in the area. Products from the refinery will be both high and low octane gasoline, kerosene, tractor fuel, fuel oil, LPG and coke.

It is planned that the materials will be procured in France with an appreciable portion of the required materials being obtained from local Argentine industry. M. W. Kellogg's London and Paris subsidiaries, Kellogg International Corp. and Societe Kellogg, will be associated in the procurement and engineering phases of the project. It is presently estimated that engineering will begin this spring.

The refinery represents an investment of more than $20 million in private risk capital. The local construction payroll for the 750 employes totaled nearly $4 million and $5 million was spent locally during construction. Approximately $1 million will be spent locally for payrolls and services each year. Permanent employment at the plant will be about 180 persons, mostly trained technicians.

The Creole Petroleum Corp. has announced that it will build a $7.5 million lubricating oil plant at the Amuay refinery on the Paraguaha Peninsula north-east of Lake Maracaibo. The 700-bpd plant is slated for 1958 completion. It will use hydrogen instead of clay in furnishing lubricating oils. The lubricants will be packaged immediately after production to eliminate tank storage, except during the



A night view of British Petroleum Company's Grangemouth oil refinery.

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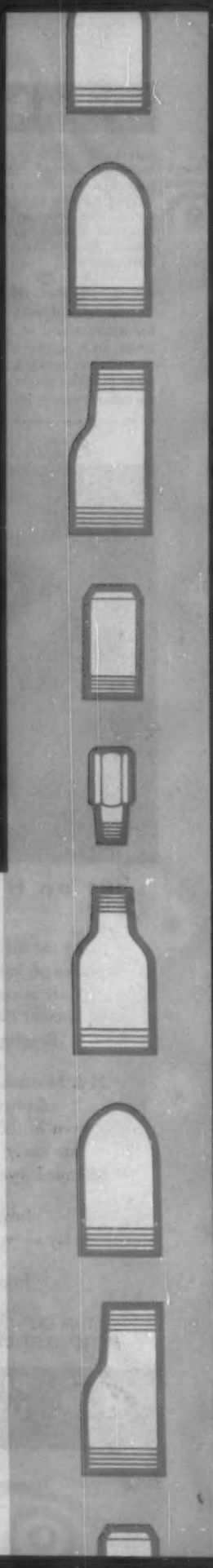

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Who's Building...

intermediate process. Plant facilities will include: phenol extraction equipment, a lube hydroforming unit, a propane dewaxing unit, tank farm and packaging equipment, and storage equipment. About 25 kinds of lubricating products will be produced. Foster Wheeler Corp. will do the building.

America Petrofina Co. of Texas has contracted with J. F. Pritchard & Co. for construction of a platformer and alkylation unit at the Mt. Pleasant, Texas, refinery. Cost totals $2 million and the company plans to spend an additional $850,000 on other refinery improvements.

Standard-Vacuum Oil Co. has, after a two year wait, received permission to build a $33.5 million refinery on the Bataan peninsula. This will be the largest private investment project in the Philippines to date. The permit was granted by the Philippines Department of Agriculture and Natural Resources to a newly formed subsidiary, Standard-Vacuum Refining Corp. (Philippines). The new plant will be built on a 500-acre tract at Limay on the east coast of Bataan peninsula overlooking Manila Bay. The plant is expected to bring about a net foreign exchange savings of about $4.5 million yearly in the first 10 years of operation. The refinery will be planned to absorb some of the country's petroleum needs, now running 43,000 bpd. It will have a design capacity of not less than 25,000 bpd. Completion will be in 1961.

Imperial Oil Ltd. will begin a $17 million expansion program next spring at the Calgary refinery. The new units, a powerformer, catalytic cracker, and an atmospheric and vacuum distillation unit, will be in operation by the autumn of 1959. Over-all capacity will be 14,700 bpd. compared with 8,000 bpd. for the present refinery.

The Texas Co. will add a 7,500-barrel capacity Udex processing unit to its refinery at Wilmington, according to W. B. Logan, manager of the company's West Coast Refining division.

Construction of the unit is expected to begin in May and be completed in February, 1959. The Ralph M. Parsons Co. of Los Angeles has been awarded the engineering contract.

Clark Oil & Refining Co. is building one of the largest fluid catalytic crackers in the Chicago area. The plant is being erected by Procon Inc. at the Blue Island, Ill. refinery. The "cat cracker," will have a capacity of 12,500 bpsd. Buildings under construction will house the blower and compressors. Refinery addition is expected to be completed in the spring. The cat cracker was designed, engineered, and licensed by Universal Oil Products Co.

Esso Standard Oil Co.'s new 7,200 bpsd Powerforming unit has gone on stream at the company's Everett refinery.

The new facilities had to be built completely "on stilts"—concrete pilings driven deep into the marshy tidelands of the area.

The new plant brings Esso's total number of Powerformers to three, with one under construction.

Wiseco Processing Plant, Inc., Bridgeport, Texas, jointly owned 80 percent by **Christie Mitchell and Mitchell** of Houston, and 20 percent by **Warren Petroleum Corp.**, Tulsa, went on stream in February.

The plant, constructed by O. L. Olsen Co., Inc., was designed to handle 150 Mcf of natural gas per day and will extract 225,000 gallons of liquids per day, of which 160,000 gallons will be LPG products and 65,000 gallons of natural gasoline. Warren expects to recover 95 percent of the butanes and between 50 and 70 percent of the propanes. Warren is operating the $4 million dollar plant and will market the products.

Industria Siciliana Lavoranzione Olii Minerali (ISLOM) has been authorized to build a plant at Palmero by the Italian government.

This project, RANSIOM'S plan to boost processing capacity at Augusta to 50,000 bpd from 34,000 bpd and three other new refineries, will add 200,000 bpd to Italy's refining capacity in the next couple of years, putting it at one million bpd.

Deutsche Erdol-Aktiengesellschaft has completed a combination UOP Platforming-Unifining unit, which includes gas concentration facilities for producing LPG.

The unit is designed to handle either a 50-50 blend of Heide-Arabian crudes boiling in the range of 210 to 355 F, or a blend of 80 percent Heide crude and 20 percent Arabian. The Unifining unit is serving as a pretreater for the Platformer, which is designed to produce a 95 F-1 clear octane blending component. Initially operating at a capacity of 2,000

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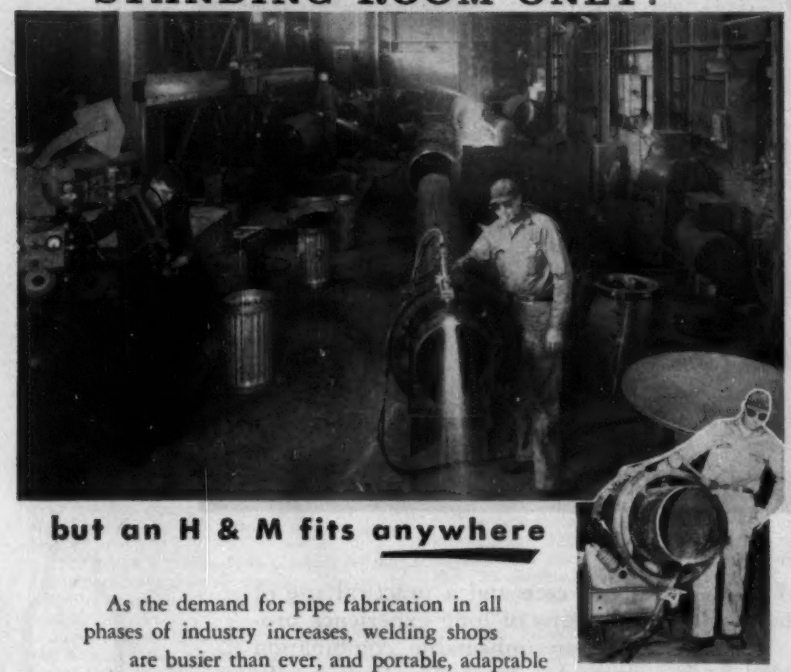

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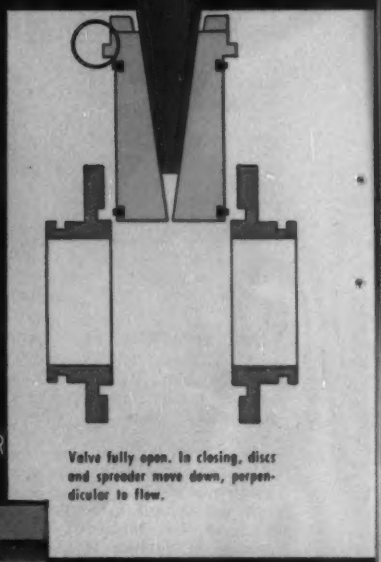
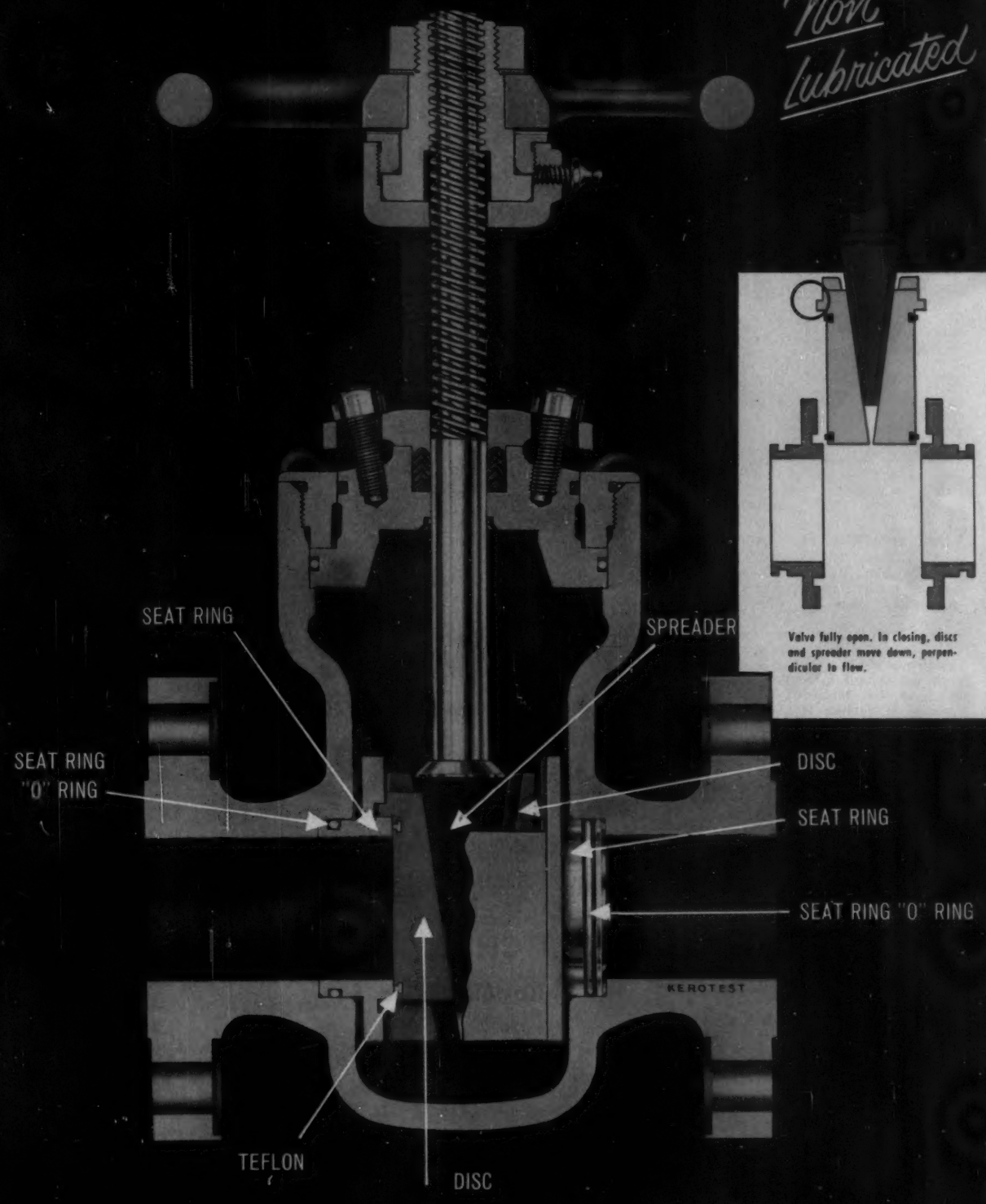


Valve fully open. In closing, discs and spreader move down, perpendicular to flow.



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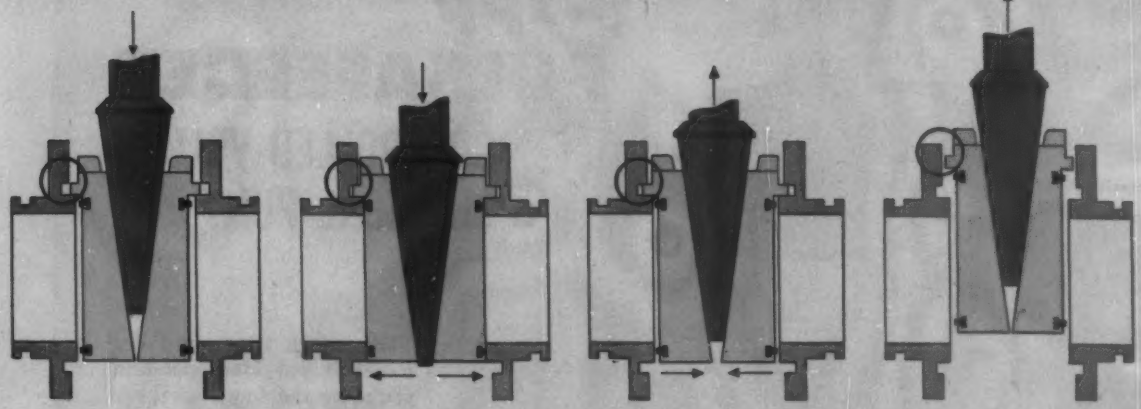

Discs are positioned without drag across seat. When disc lug rests on seat ring, continued downward motion of spreader moves discs parallel to flow.

Valve fully closed. Spreader holds discs vapor-tight against seat rings.

Valve begins opening. Seated discs are retracted with the same parallel motion—again with no drag against seating surfaces.

Discs fully retracted, and assembly rising. Upward motion does not begin until discs are clear of seat ring.

More than two years of laboratory and field testing have clearly demonstrated the fact that the new KEROSEAL offers advantages not found in any other valve.

The KEROSEAL valve gives a vapor-tight seal without the continued and costly use of sealing lubricants. An effective new method of guiding the disc assembly, completely independent of the valve body, maintains clearance between discs and seat rings during operation, eliminating wear, frictional drag, wiping, and consequent galling of the seating surfaces.

Primarily, these advantages are the result of an entirely new principle of operation. The stem carries a spreader, on which are mounted a pair of discs. A Teflon sealing ring is mechanically bonded to each disc.

When the valve is being closed, the discs move downward, without friction. This downward travel automatically ends when discs are correctly positioned in relation to the seat ring. At this point, further movement of the stem initiates the spreader action, forcing the discs against the seat rings.

In opening, the first movement of the stem retracts the discs so that they clear the seat rings, and further movement raises the discs until they reach the fully open position.

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NO LEAKAGE
NO CONTAMINATION
NO PRIME LOSS
NO STUFFING BOX

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bpsd, the Platformer eventually will be operated at a 4,000 bpsd design capacity.

The Platformer is the sixth operating in Germany. It was constructed by Procon (Great Britain), Ltd., in cooperation with Edeleanu Gesellschaft m.b.h., Frankfurt/Main, and was designed, engineered, and licensed by Universal Oil Products Co., Des Plaines, Ill.

Lone Star Producing Co., a subsidiary of Lone Star Gas Co., plans to build a natural gas treating plant and gas gathering system for its production facilities in Atascosa County, Texas, at a cost of about $3.75 million.

The plant will use a hot potash-amine method of treating the gas to make it suitable for burning. Located about 50 miles southeast of San Antonio, the plant will have a capacity of about 100 million cubic feet of treated gas daily.

Lone Star has a 20-year contract for sale of the gas to United Gas Pipe Line Co., which is expected to average from 50 million to 65 million cubic feet of the gas daily. Initial delivery to United is scheduled to begin in about six months on completion of the plant.

Continental Oil Co. has announced completion of a $6.25 million coking unit at Lake Charles, La. The unit will be operated by Continental Oil although it is owned by the Lake Charles Chemical Corp.

The new facility will be operated as an integral part of Conoco's Lake Charles refinery. It will produce approximately 85,000 tons annually of coke for industrial use and 4200 barrels daily of refinery stock for manufacturing motor gasoline.

Texas Natural Gasoline Corp. of Tulsa and **Tennessee Gas Transmission Co.** of Houston will jointly construct a natural gasoline plant south of New Orleans, La.

Each company will own an undivided one-half interest in the plant and its products. Texas Natural Gasoline Corp. will supervise construction and will be plant operator upon completion.

Fluor Corporation, Ltd., will do the building beginning in March, 1958 and ending in Nov., 1958. The plant will process natural gas from fields in Southern La. and the Mississippi River Delta area. It will extract natural gas liquids from 150 million cubic feet of gas per day. The natural gas liquids will be recovered from the gas by a combination absorption refrigeration process operating at —20°F. Product fractionation facilities will be designed to handle about 380,000 gallons per day of liquid products, which is the total volume of liquid products that will be produced when additional gas becomes available in the area. The natural gas liquids produced will include propane, normal butane, isobutane, and natural gasoline.

Plant production is estimated to be approximately 120,000 gallons per day and this volume of products will increase as additional gas is connected.

The Petro-Tex Chemical Corp. of Houston and **Plymouth Oil Co.** of Pittsburgh today announced the signing of a long-term agreement for the production of alkylate. The 3,000 barrel per day Sulphuric Acid Alkylation plant is be-

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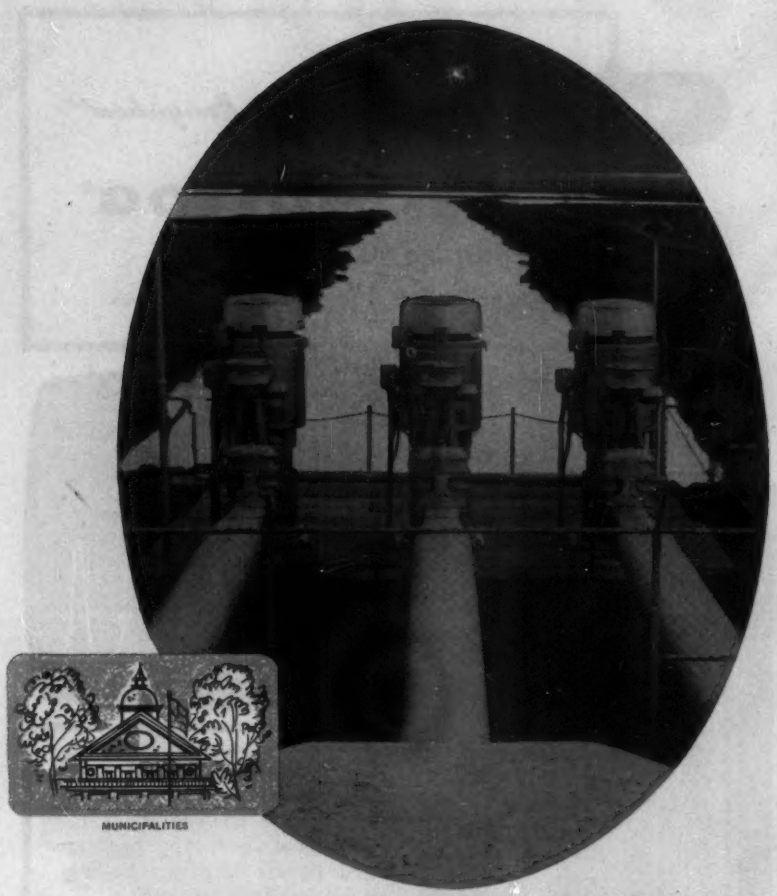

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ing constructed by Petro-Tex at its Houston location. Completion is scheduled for early 1959.

Part of this capacity will be used to produce alkylate for Plymouth Oil Co. from feed supplied by Plymouth. Petro-Tex will make alkylate from butylenes from its butane dehydrogenation plant.

British Hydrocarbon Chemicals Ltd. has completed, and is building, several plants for producing phenol from cumene. The new plants are located in the U.S.A., Belgium, Canada, France, Germany and Japan, and will process phenol by the new method used in practically all new major phenol plants built in recent years. The process differs from the classical method of manufacturing phenol, in that neither sulphuric acid or chlorine are required. Instead, benzine is first made to combine with propylene to form isopropyl benzene (cumene). Cumene is then oxidized to phenol and acetone. The conversion is very efficient and the two end-products can be separated easily in a high state of purity. Labor costs are low as the process lends itself to automatic control.

Eurochemic, a joint company set up by 12 member countries of the Organization for European Economic Cooperation, will build a nuclear fuel reprocessing plant at Mol, Belgium. The $12 million plant is slated for completion in 1961, and will have a capacity of 100 tons of uranium per year.

Tellepsen Construction Co. will rebuild part of the fire-damaged Wooster plant of the United Rubber and Chemical Co. near Baytown. The section was destroyed recently in a $1.5 million blaze. Reconstruction of the plant will be on a crash basis with 120 days allowed for building. Destroyed was a three-story pigment preparation building and a one-story warehouse.

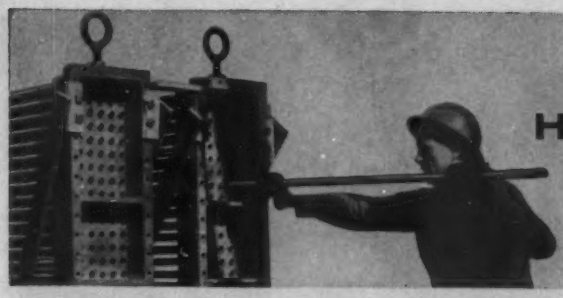
Humble Oil and Refining Co., Houston, has completed its new benzene plant in Baytown, Texas. It is designed to produce about 30 million gallons of high purity benzene a year, and is said to be one of the largest of its kind in the world. The plant is integrated with other refinery operation and the feed stock for the unit will come from a nearby hydroformer.

Esso Standard Oil Co. is putting a new refinery on stream in November, 1958 at Cologne, Germany. The $83.3 million installation will produce 70,000 bpd. Further expansion is now being planned.

Sinclair Refining Co. is installing an MEK dewaxing-deoiling unit at its East Chicago, Ind. refinery. The unit is being erected by Badger Manufacturing Co., and is slated to go on stream late in 1958.

Standard Oil Co. of California, Western Operations, Inc., will shortly put into operation new facilities to serve the fast growing petroleum requirements of Tahiti and French Oceania. Standard said a new bulk storage plant is being built at Papeete on Tahiti which will enable delivery of petroleum products by tanker shipment instead of by 55-gallon steel drums, as in the past.

To provide the wide variety of products that will be needed, the plant will include

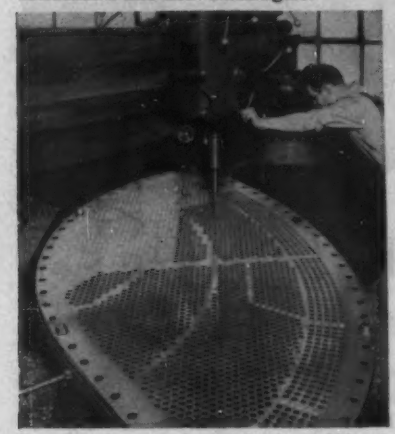


CONDENSER AND HEAT EXCHANGER CLINIC

Edited by Arthur W. Tracy, Metallurgical Engineer
The American Brass Company, Waterbury, Conn.

Selecting alloys for rolled tube sheets and baffles

Tube sheets and baffles are available from The American Brass Company in a wide variety of shapes, sizes and alloys to meet the problems of corrosion, pressure, and temperature encountered in condensers and heat exchangers.



Reaming a large condenser tube sheet of Naval Brass-450.

The following Anaconda alloys are those most widely used for tube sheets and baffle plates.

Leaded Muntz Metal-274 has good strength, stiffness and elasticity. It machines well and is the most commonly used tube-sheet metal. Leaded Muntz Metal hot rolls easily and can be manufactured in very large sizes. Many of the other tube-sheet alloys are superior to Leaded Muntz Metal in corrosion resistance and are used in preference to it for that reason. However, tube sheets are necessarily so thick that a long time elapses before they are affected by corrosion to the extent that their strength or usefulness is impaired.

Naval Brass-450 is an alloy of the same general type as Leaded Muntz Metal but includes approximately 0.75% tin in its composition. The tin content increases the alloy's resistance to corrosion, and makes it preferable to Leaded Muntz Metal, especially at higher-than-normal working temperatures. Hot-working properties of Naval Brass are similar to those of Leaded Muntz Metal.

Arsenical Admiralty-439 is resistant to dezincification corrosion and can be used where its higher resistance to corrosion is required, especially in process equipment.

Ambraloy-917 is available for use where strength and corrosion resistance superior to Naval Brass and Admiralty Metal are desired, as in oil-cooler tube sheets.

Cupro Nickel, 10%-755 and Cupro Nickel, 30%-702 are used extensively with tubes of similar composition in marine condensers and process heat exchangers.

Baffle and Support Plates for use in oil-refinery equipment are most often of Leaded Muntz Metal and Yellow Brass. For more severe applications, Admiralty, Naval Brass, Cupro Nickel, Copper and Everdur® are often employed.

Rolled Plates Superior. Anaconda sheets, plates, and circles are produced by the rolling process. They are commercially flat, accurate in dimensions, and free from the surface imperfections and porosity often prevalent in cast plates.

Standard Sizes. The American Brass Company makes plates for condenser tube sheets of copper and a number of copper alloys in rectangular sizes up to 156 inches in width and weights up to 15,000 pounds for any shape that can be cut from such sheet. The maximum standard limits for circles are 160 inches in diameter and 11,000 pounds in weight. Half circles can be produced up to 13,000 pounds in weight.

Rolled circles of Ambraloy-917, 2" thick, for water-to-water heat exchanger tube sheets requiring superior strength and corrosion resistance. Such circles can be furnished up to 5" thick, offer savings in material cost over comparable circles produced by the forging process.

Special jobs. When specifications call for extremely large plates or special alloys for special applications, The American Brass Company will gladly cooperate in the solution of such problems. For further information on Anaconda Condenser Tubes or Tube Sheets write: The American Brass Company, Waterbury 20, Conn. 5870

Nominal compositions of Anaconda condenser tube sheet and plate stock

Alloy	Copper %	Zinc %	Tin %	Nickel %	Aluminum %	Lead %	Manganese %	Phosphorus %	Silicon %	Iron %	Arsenic %
Leaded Muntz Metal-274	60.0	39.40	—	—	—	0.60	—	—	—	—	—
Naval Brass-450	60.0	39.25	0.75	—	—	—	—	—	—	—	—
Arsenical Admiralty-439	71.0	27.96	1.0	—	—	—	—	—	—	—	0.04
Ambraloy-917 (Aluminum Bronze)	82.0	—	—	5.0	9.50	—	1.0	—	—	2.50	—
Cupro Nickel, 30%-702	68.9	—	—	30.0	—	—	0.60	—	—	0.50	—
Cupro Nickel, 10%-755	88.35	—	—	10.0	—	—	0.40	—	—	1.25	—
Phosphorized Copper-103	99.90+	—	—	—	—	—	—	0.02	—	—	—
Everdur®-1010	95.80	—	—	—	—	—	1.10	—	3.10	—	—

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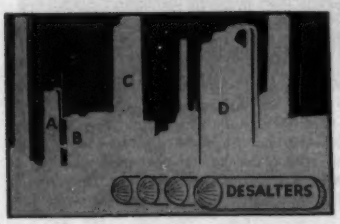
ANACONDA®

Tubes and Plates for Condensers and Heat Exchangers Made by The American Brass Company

For more data on advertised products, use Readers' Service Cards, last page.

The new Delaware Refinery . . .

Where Tidewater placed high nickel alloys to combat corrosion in world's largest crude unit



This is the crude unit . . . world's largest . . . in the ultra-modern Delaware Refinery.

It's the last word in corrosion protection. In engineering this protection, The Tidewater Oil Company and C. F. Braun & Co. took full advantage of high nickel alloys. In general, they used these materials to combat corrosion by dilute mineral acids and by the sulfur and naphthenic contents of the feeds. The schedule below gives details.

For further information . . . for help in your own corrosion prevention engineering . . . write Inco's Development and Research Division.

The International Nickel Company, Inc.
67 Wall Street — New York 5, N. Y.

Schedule of high nickel alloy use* in the crude unit at Delaware Refinery

Key	Equipment	Location	Principal Corrosives	Material
A	Gasoline Col.	Shell and trays above tray 13	H_2S, aqueous HCl	Monel alloy
		Nozzle sleeves in OH accum.	H_2S, aqueous HCl	Monel
		Water draw pot	H_2S, aqueous HCl	Monel-clad steel
		Foul water pump	H_2S, aqueous HCl	Monel alloy
		OH-to-receiver piping	H_2S, aqueous HCl	Monel alloy
B	Gasoline Stab.	Shell and trays above tray 7	H_2S, aqueous HCl	Monel alloy
		Shell and trays below tray 8	Naphthenic acid	Inconel alloy
		Nozzle sleeves in OH accum.	H_2S, aqueous HCl	Monel
		Reboiler tubes, sheets, flohead	Naphthenic acid	Inconel alloy
		Reboiler shell	Naphthenic acid	Inconel-clad steel
		OH-to-receiver piping	H_2S, aqueous HCl	Monel alloy
		Reboiler liquid and vapor piping	Naphthenic acid	Inconel alloy
C	Atmospheric Col.	Foul condensate pump	H_2S, aqueous HCl	Monel alloy
D	Vacuum Col.	Condensate pump bowls and impellers (1st, 2nd, and 3rd stage)	H_2S, aqueous HCl	Monel alloy
All — elements		Foul condensate pumps	H_2S, aqueous HCl	Monel alloy

*Where temperatures go above 500°F. nickel-containing Type 316 stainless and stainless-clad steel is also extensively used in this unit.

INCO NICKEL ALLOYS

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building...

a warehouse for packaged goods, and eight tanks totaling 53,000 barrels capacity. Sales will be handled by a recently formed Tahitian group.

Location of the plant is Papeete Harbor's Point Fare Ute, near the main ship dock. The plant will be stocked by Standard's tankers via pipe lines from a new wharf.

Reichold Chemicals Co. will build its fourteenth U. S. plant in Hampton, S. C. The first units to be constructed are facilities to produce 30 million pounds of formaldehyde annually, and a large methanol terminal. Plant is expected to go on stream by July, 1958.

Esso Standard Oil Co. will put a 27,000-bpd power former into operation at its Baton Rouge refinery. The unit is part of a $46 million construction and modernization program underway there. The powerformer is slated to go into operation next summer.

Socony Mobil Oil Co., Inc., has announced that its Venezuelan affiliate will build a wholly-owned $28 million refinery in that country.

The new installation will be located at El Palito, about eight miles west of Puerto Cabello. Construction is scheduled to begin early this year and to be completed late in 1959.

The refinery will be built on a site owned by Socony Mobil de Venezuela at the terminus of the Barinas El Palito crude oil pipeline, which the company completed last November.

Rated initial capacity of the refinery will be 40,000 bpd. Its crude oil will come initially from the Silvestre Field, near Barinas, but the plant will be able to process other crude oils available in the area.

Gulf Oil Corp. today announced plans to build an alkylation plant at its Toledo Refinery. The new facilities will combine light hydrocarbons produced in other refinery operations, to produce approximately 2,000 bpd of alkylate.

The Toledo unit will be Gulf's fifth alkylation plant. The new plant will consist of a reactor section and four fractionating towers, the highest of which will be 140 feet. It will use sulfuric acid as a catalyst to promote the alkylation reaction.

The M. W. Kellogg Co. has been named as the contractor to build the new unit. Construction is scheduled to start in the summer of 1958, and operations are expected to begin during 1959.

Arkansas-Louisiana Gas Co. will build a $3 million hydrocarbon extraction plant at Magnolia, Ark. The plant will extract 78,000 gallons per day of ethylene for marketing to the plastics industry. The new plant is scheduled for completion in mid-1959.

ANIC, which is controlled by E.N.I. (Ente Nazionale Idrocarburi), economic agency of the Italian state, is building a Houndry dehydrogenation process unit at Ravenna, Italy. ANIC is building plants at Ravenna for synthetic rubber and nitrogen fertilizers. It will have a nominal design capacity of 20,000 tons per year of butadiene.

SUREST PROTECTION
for Volatile Liquids in Storage

Safeguard Your Tanks with
BS&B Lightweight
Tank Vents and Flame Arrestors

BS&B TANK VENT (Type 76-16) shown above features floating seal for positive shut-off under both pressure and vacuum, without using the weight of the hinged cover. Vapor pressure within the tank (or atmospheric pressure in the case of vacuum) maintains seal. Cover and major internal components are aluminum with stainless and plated steel hardware. Plastic coated bases are cast iron. These vents mount to 125-lb. ASA bolting circles. Sizes 6" through 12".

For free vent systems. May be mounted either horizontally or vertically. End connections are 125-lb. ASA flanged for mounting to open vent lines of process vessels. Flamebank end flanges are identical to those of the Type 76-17 Arrestor Vent bases (at right). Light weight, maximum venting capacity and servicing ease are important features of the Flame Arrestor.

Combines the features of the other two types described here. Functions both as a tank breather and a cartridge-type flame arrestor to prevent ignited vapors from flashing back into the tank. Flame bank is secured by two quick-opening V-clamps for easy access to unit for inspection and servicing. Normal venting with the flame bank removed is maintained by simply securing the top unit to the base with one V-clamp. Internals of flame bank are alternate layers of flat and corrugated aluminum strips, in a continuous roll.

BS&B

Ask your BS&B representative for Catalog 76-16 or write...

BLACK, SIVALLS & BRYSON, INC.
Safety Head — Vent Valve Division, Dept. 2-F3
7500 East 12th Street • Kansas City, Missouri

For more data on advertised products, use Readers' Service Cards, last page.

NEW CHEMINEER AGITATOR KIT CONTROLS MIXING VARIABLES

In scale-up, this complete laboratory experimental agitator kit provides everything you need to make fast, accurate determinations of mixing requirements; or use it as a flexible component in bench scale processes. All variables are under your control, and the illustrated handbook supplied makes it easy to specify or set up the correct agitation characteristics.

Full-scale geometric, kinematic, and dynamic similarities of Newtonian and non-Newtonian fluids are duplicated in Model ELB kit pilot plant and bench scale-up tests.

Contained in a sturdy, portable case, Model ELB features a constant speed ¼ hp. motor with a micrometer controlled variable speed transmission. Linear dial-speed relationship gives 0 to 1100 rpm, with low speed torque multiplication. Also included are 22 calibrated impellers, 3 shafts, and universal mounting.

A dynamometer accessory gives horsepower requirements directly. Complete line of other accessories available. Handbook alone available for $1.50 postpaid. Ask about our rental-purchase plan. WRITE FOR FREE BULLETIN 109.

See our industrial equipment in CEC. Complete catalog on request.

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Reviewing New Books . . .

"Applied Statistics For Engineers"

Engineers, especially in chemical and processing fields, will find in this book background and examples of statistical problems to enable them to apply statistical analysis to engineering data. The book deals with treating engineering data for correlation, precision, and analysis of experimental factors. It emphasizes engineering applications rather than theory, and provides a number of illustrative examples. A review of probability theory and frequency distribution is included.

It describes the method of drawing the "best" line through the data and the method of determining how well the line fits the data, how much variation in the data is eliminated by the line and by the correlation, and how much variation still remains. There are also detailed discussions of curvilinear correlation, analysis of the variance, and interpretation of the analysis of variance.

(McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y., 250 pages, $9.50.)

Accident Prevention

API Accident Prevention Manual No. 13B, Cleaning Mobile Tank Cars Used For Transportation of Inflammable Liquids, is now available.

It is a companion piece to a similar publication covering tank vehicles, which was issued about a year ago.

The new bulletin outlines measures which should be taken to protect personnel from exposure to harmful vapor concentrations, or oxygen deficiency. It also suggests measures which should be taken to avoid accidental ignition of flammable vapors which may be present during certain phases of tank cleaning and repair operations.

Data in the manual is confined to non-pressure-type tank cars. Data does not include information on tank cars used for transportation of liquefied petroleum gas, acids, caustics, or oxidizing, reactive or unstable materials.

(American Petroleum Institute, 50 West 50th Street, New York 20, N. Y., $1.00 per copy.)

Nuclear Glossary

The American Standards Association and The American Society of Mechanical Engineers announced that a volume titled Glossary of Terms in Nuclear Science and Technology has been approved as an American Standard, and will be published as such by ASME.

The book is designed to provide a common language among medical men, engineers, chemists, physicists, biologists and others working with the atom. It includes three categories of terms: 1) those invested expressly for the field of nuclear energy; 2) those borrowed from other fields and employed here with different meanings; 3) and those used elsewhere, but which may be unfamiliar to nuclear workers.

(American Society of Mechanical Engineers, 29 West 39 Street, New York, 188 pages, $5.00.)

Disposing Refinery Wastes

Volume III, Chemical Wastes, of the Manual on Disposal of Refinery Wastes, is available through the American Petroleum Institute. This is the Third Edition, 1958.

This manual presents recommended practices and procedures for the utilization, treatment and disposal of chemical wastes from petroleum refineries. A summary is included on the sources of chemical wastes and methods of waste control and waste treatment. It also contains a chapter on the recommended handling of specific refinery wastes. Tables, diagrams, and illustrations are included.

(American Petroleum Institute, 50 West 50th Street, New York 20, New York, $2.00 a copy.)

Safety Instruction Cards

A handy, compact check list of safe practices and accident prevention data, 3" x 5" cards furnish basic information on general industrial, special industry, traffic, motor transportation and off-the-job safety subjects. Dozens of uses . . . gives employees the cards that pertain to their jobs, pass them out at safety meetings to help you make your points, rely on them whenever you have to write a speech or a bulletin or a job analysis.

The Industrial Set consists of 470 Basic Industrial cards plus the Special Industries cards which apply to the user's industry or operation. Sets are available with a two-way index, a set of numerical dividers and a metal file case. Quantities of individual cards may also be ordered.

The set contains: basic industrial set, metal case, guide cards, and a set of the special industry cards for petroleum.

(National Safety Council, 425 N. Michigan Avenue, Chicago 11, Ill., 1-9, $9.50; 10-99, $8.85; 100-up, $8.25.)

External Ultrasonics

This volume, The Feasibility of Using Wholly External Ultrasonics To Measure Fluid Flow within Thick-Walled Metal Pipes, discusses ultrasonic systems for external measurement of pressurized liquid within a pipe, proposed recently by Navy researchers. The flowmeter operating through pipe walls could be used where liquid is corrosive or is contained under high pressure or at high temperatures.

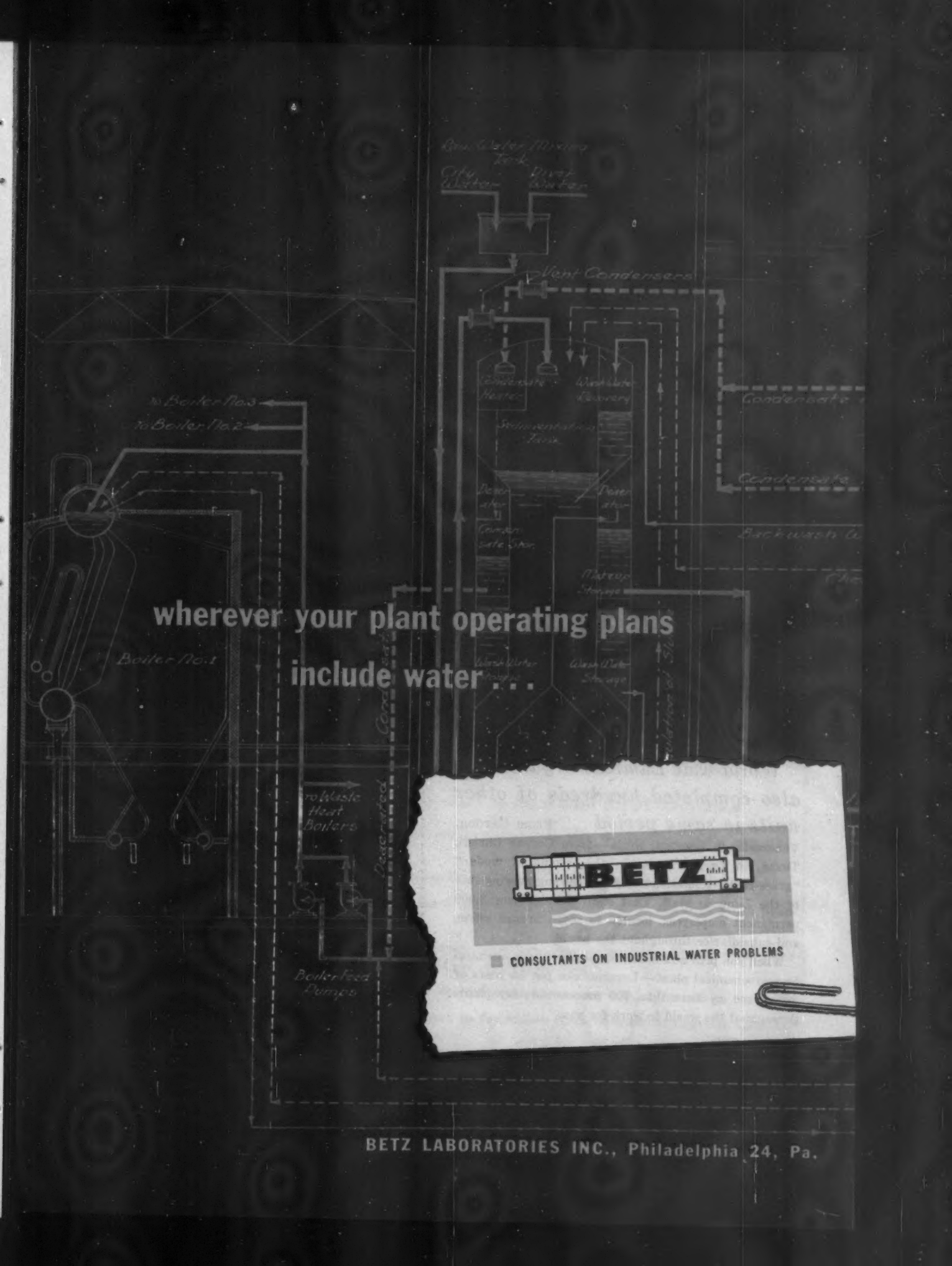
The report describes three proposed configurations for the flowmeter. A block diagram for the electronics system is suggested, along with a scheme to minimize the effect of sound speed on the flow indication. A scheme for mechanical construction of two configurations is also included.

(OTS, U. S. Department of Commerce, Washington 25, 42 pages, $1.25.)

API Bulletin 2511 On "Precautionary Labels"

This bulletin defines the terms of and gives instructions for the preparation of petroleum warning labels. Publication of the new bulletin was announced by the Department of Technical Services of the American Petroleum Institute.

(API, 50 West 50th St., New York, $1).



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World-wide Lummus Organization also completed hundreds of other units in same period . . . From Cardon, Venezuela, to Bombay, India—from Corpus Christi, Texas, to Turku, Finland—this string of modern "grass-roots" refineries testifies to the engineering skill of the Lummus staff. That staff includes over 3,000 permanent employees, located in seven branch offices and subsidiaries throughout the world.

When you plan a new facility—oil refinery, chemical or petrochemical plant—Lummus can put 50 years of experience on more than 700 process-industry plants throughout the world to work for you.

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2. Refinery for Koppartrans Oljeaktiebolag at Gothenburg, Sweden
3. Refinery for Venezuela Gulf Refining Company at Puerto La Cruz, Venezuela
4. Refinery for Societe Generale des Huiles de Petrole at Dunkirk, France
5. "Portable" refinery for U. S. Navy Department
6. Lube oil refinery for Cit-Con Oil Corporation at Lake Charles, Louisiana
7. Refinery for International Refineries Inc. at Wrenshall, Minnesota
8. Refinery for Vacuum Oil Company Ltd. at Coryton, England
9. Refinery for Burmah-Shell Oil Company at Bombay, India
10. Refinery for Standard-Vacuum Oil Company at Bombay, India
11. Refinery for Standard Oil Company (Indiana) at Mandan, North Dakota
12. Refinery for Suntide Refining Company at Corpus Christi, Texas
13. Refinery for Commonwealth Refining Company at Ponce, Puerto Rico
14. Refinery for Esso Standard Oil Company at Antwerp, Belgium
15. Refinery for Caltex at Visakhapatnam, India
16. Refinery for Neste Oy at Turku, Finland
17. Refinery for Irish Refining Co., Ltd., Cork, Ireland
18. Refinery for Esso Standard Française, Bordeaux, France
19. Refinery for Purfina Mineraloelraffinerie A.G., Duisburg, Germany

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Staff Report

Do You Motivate Safety Habits?

If the answer is "no," be sure to check this excellent plan for accident prevention that can work in your refinery.

ONE OF THE major reasons for a high accident frequency rate is the negative or indifferent attitude of the individual employe toward his company's safety program. And one of the most disturbing aspects in the present stage of motivational programs is that in many companies progress has come to a standstill.

The reasons may be lack of adequate financial support, a certain degree of complacency on the part of those who are carrying out the program or a lack of vision on the part of those who are responsible for administration. Certainly, if the published frequency rates are any indication, safety programs of many companies could be improved.

The fact is, in spite of increased resources in the literature on the subject, and improved training instruments and techniques at present available, motivational programs in many aspects have progressed very little in the past few years.

For those whose accident frequency rate is sky-high in comparison with their counterparts in industry, the objective should be clear. That is, set up some system of direct or indirect safety education, or both, not too complicated, to motivate certain desirable safety conduct habits.

Outline Your Objections. To decide the conduct habits desired, a list should be drawn up which appeals to those who administer the safety program. This list should be reviewed by all concerned and, in addition, compared with other similar lists from current literature. It may be found that there is little correlation between the lists, but by taking the habits which are listed most frequently and tempering them with judgment based on the company's needs, a final list can be decided upon.

Such a list could include, for a company whose record shows many eye and hand injuries, the following desired habits:

A. For Eye Injuries:
   1. Wearing of goggles
   2. Right type of goggle
   3. Use of colored glasses
   4. General eye protection

B. For Hand Injuries:
   1. Danger of damaged tools
   2. Proper handling of materials
   3. Use of gloves
   4. General finger protection

Select Your Methods. Two problems will now be apparent. First, what method or methods shall be used to motivate the employe to develop the desirable habits, and second, what materials shall be used.

A careful study of the methods now in use by many companies will show that most are based knowingly or unknowingly upon a few basic laws of psychology. Any effort towards the motivation of desirable safety conduct must take into account and make full use of the laws of learning, the laws of habit formation, the arousing of feeling so strong it might be called emotion, and as much opportunity as possible to practice the desired safety conduct mentally and/or physically.

Choose Your Materials. The problem of what materials to use is not so difficult to solve. The National Safety Council and other national and local safety organizations can supply safety directors with material of any type

Seven Keys to Successful Safety Motivation

1. Communicate to employes the desirable habits you wish developed.

2. Arouse emotions in favor of the proper safety conduct.

3. Find as many occasions as possible to put the conduct in practice.

4. Have employes read and discuss suitable literature driving home the idea of the conduct desired.

5. Emphasize desired conduct whenever safety meetings are held.

6. Ask employes to formulate rules of conduct bearing upon the central thought.

7. During meetings, ask employes to relate stories and experiences that illustrate happy results from proper conduct, or disastrous results from improper conduct.

and description. A partial listing of materials that can be used includes:

1. For incidental learning—use of pictures, drawings, posters, mottoes etc., which affect the mind more or less by auto-suggestion.

2. Literature—full use of editorials, stories, feature articles and memory joggers which illustrate and drive home as concretely as possible the desired safety conduct.

3. Biography—incidents from the lives of employes and notable men and women told in such a way as to arouse the desire to follow the same line of safety conduct.

4. On-the-job safety meetings with exhibits and/or pictures to create a "right safety conduct atmosphere."

Since the material is available to everyone, the difference in the accident frequency rate between two like companies must rest on the motivational program of each; and, since many companies have the same type of motivational program, the failure or succes must rest on the shoulders of those administering the program.

Where Safety Programs Fail. It is not the purpose here to criticize those who administer safety programs. It is well known that they, as a group, are hard and diligent workers. Evidence seems to point to the fact that most safety personnel are victims of industrial progress.

Because individual companies have grown so large, the safety functions are quite complex—so complex that specialized administrative talents must be employed to direct them. The result is that the director's primary function, namely, safety instruction, is neglected.

Offers of safety positions are usually accepted because they carry additional prestige and compensation. Few in the safety field are able to resist the additional prestige and monetary reward. One result is that the safety instruction service given by the director is all too often slighted by the more pressing administrative part of his task.

The director, of course, is expected to attend meetings of the administrative group, and more often than not whenever these meetings and other administrative duties call him away from his "pupils" little attention is paid to providing a competent substitute. Frequently, safety programs are left to drift without guidance or leadership.

Nevertheless, to insure the success of any motivational program the administrator or his substitute must have a working knowledge of, and the desire to apply, the aforementioned psychological laws.

There are many individual laws of learning and habit formation, but for our purpose here the three basic rules of each will be used.

The motivational plan outlined below takes into consideration the method to be used, the laws of learning and habit formation, and the necessary materials.

STEP I

A. First Law of Learning.

Readiness. Before anyone can develop desirable habits and conduct he must be ready to listen and learn.

B. First Law of Habit Formation.

Focalization. The preface to all habit formation is the bringing into the focus of attention that which you wish them to develop. So, focus their attention upon the desired conduct.

C. Method.

Arouse interest and desire.

D. Materials.

Arouse the interest and desire by presenting incidents from safety literature, lives of well-known people or actual employe experiences which emphasize the habit that needs to be developed. Similar material can be used to illustrate the unfortunate accidents that occur when the desirable habit is not developed.

STEP II

A. Second Law of Learning.

Effect. Here the reactions to the material used in Step I are important. If the reactions are of a positive nature, the response or habit tends to be retained. If the response is negative, the desirable habits are not developed.

B. Second Law of Habit Formation.

Emotional Prompting. Seize upon the positive emotions elicited in Step I and direct them toward the desired habit.

C. Method.

Change desire into strong emotion.

D. Materials.

To change the desire to develop desirable safety conduct into strong feelings, even emotion, the use of stories, slogans, life situations and movies is recommended. One of the basic personality truths is that most people react emotionally. Statistics, facts and other raw data should be expressed with emotional adjectives. This appealing to man's basic needs is highly desirable. Stress the fact that accidents can cause harm to family, home, self and a man's prestige.

STEP III

A. Third Law of Learning.

Practice. Stress the fact that each employe must practice his safety habits each day.

B. Third Law of Habit Formation.

Use Every Opportunity. The employe should be encouraged to keep in mind the desired safety habit and to grasp every possible opportunity to practice the required conduct in as many different situations as possible.

C. Method.

Change the emotion into habit.

D. Materials.

On-the-job materials. The employe must apply the theoretical aspects of the safety program in naturally occurring situations or in manufactured situations, such as simulated hazards and preventative drills.

"Indirect" Safety Control. The above is a "direct" method of instilling desirable safety conduct in the employe. As to an "indirect" method, the safety director must use every occasion which presents itself to inculcate the specific safety conduct. To keep the desired conduct constantly before the employes, signs and posters should be printed in large type and bright colors and posted in conspicuous places as long as that specific conduct is being considered.

In addition, the safety director can make a thorough search of all literature and catalogues, and prepare a card index record of all material which has any bearing whatever upon the conduct and which might be of use in carrying through the campaign. ##

Six Types of Contracts Must Be in Writing

The law provides that certain types of contracts be in writing to be enforceable. Following is a brief description of each:

1. Contracts of executors and administrators who become personally bound for the debts of the estates that they are administering.

2. Contracts in consideration of marriage.

3. Contracts to answer for the debt, default, or miscarriage of another person.

4. Contracts involving the sale of real estate.

5. Agreements that may not be performed personally within one year.

6. Agreements to sell personal property above a certain amount, usually $50, unless there has been part payment or part delivery.

What You Should Know About Refinery Contracts

"Refinery executives are not expected to be legal experts, but they should know the fundamentals of contract law."

Dr. Earl W. Mounce
Professor of Law, University of Maryland

Dr. Robley D. Stevens
Management Consultant, Washington, D. C.

HOW MUCH business law should a refinery executive know?

This is a difficult question to answer with any degree of finality. However, you should certainly keep in mind that business law governs your everyday refinery activities much more than you think.

You may not realize it, but you probably enter into hundreds of business contracts for the buying and selling of refinery products—oral, implied, or written—during the course of a year. After the order is written, you have incurred legal liabilities. And, you also have created certain rights for yourself.

For the daily guidance of refinery officials, following are several practical definitions of contract rights and liabilities.

You are not compelled by law to enter into a particular refinery business contract. If you should enter into such a contract, the rights and duties which you have under the contract will be derived from your "voluntary" agreement thereto.

The court will not make a contract for you. If, however, you and the other party voluntarily enter into a legally enforcable contract, the court will interpret and enforce it as such.

To protect yourself against making unnecessary refinery business contracts you should know the definition of a contract. Simply stated, *"A contract is a promise or set of promises for the breach of which the law gives a remedy, or the performance of which the law in some way recognizes as a duty."*

Classifications. The **contract-under-seal** is the common example of a formal contract. It was the first type of contract to be recognized and enforced by the court. It had to be in writing, signed, and sealed. Today, however, in a number of states the seal has been abolished by statute.

A contract is said to be an "**express**" contract if the parties to the contract expressly state the terms of the agreement. The "intention" of the parties to a contract and the terms of the agreement may be in writing or orally entered into.

A contract "**implied**" is a contract inferred from the acts or conduct of the parties and the surrounding circumstances involved. The terms of the contract and the intention of the parties are not expressed orally or in writing, but the actions and conduct of the parties indicate an intention to contract.

You prove an "express" contract by introducing the written contract, or, if your contract was orally entered into, by introducing evidence to what the parties said.

You prove an "implied" contract by introducing evidence as to the acts of the parties.

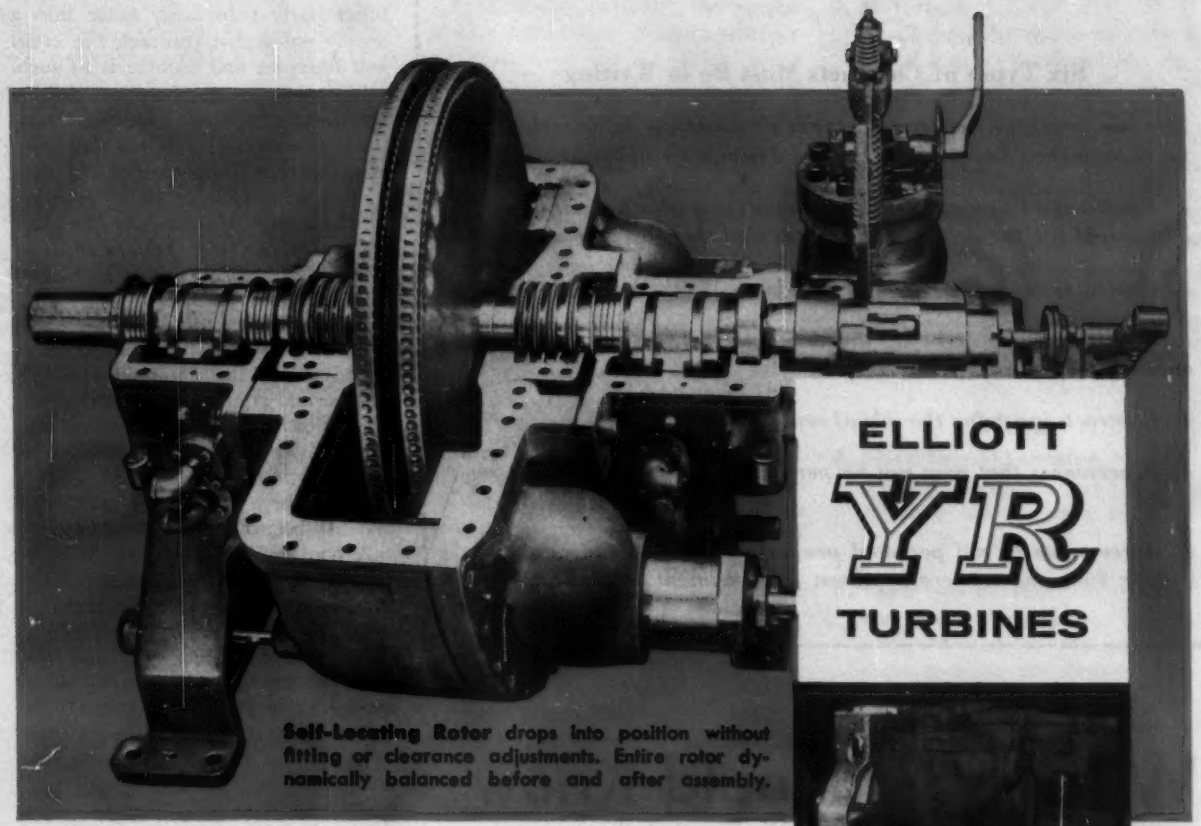
An "**executed**" contract is one that has been fully and completely performed by all the parties to the contract.

An "**executory**" contract is one that has not been performed by either party. Under its terms, performance is to take place at some future time.

A "**bilateral**" contract is one in which the parties exchanged mutual promises—the promises were reciprocal. There is an exchange of a promise for an act. The offeror promises an act or forebearance for an act on the part of the offeree.

A "**void**" contract is one that has no legal effect—one the court will not enforce.

A "**voidable**" contract is one that



Self-Locating Rotor drops into position without fitting or clearance adjustments. Entire rotor dynamically balanced before and after assembly.

ELLIOTT

YR

TURBINES

5 design features insure ...easy installation ...easy maintenance

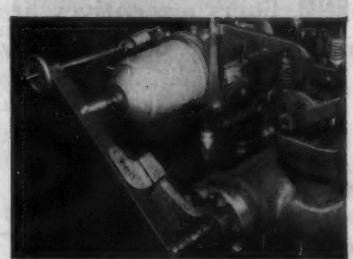
Dependability in long-term, continuous service is the principal reason why Elliott mechanical drive turbines have won such universal acceptance as prime movers for process and water pumps, fans, compressors and other driven machines.

But there's more to it than that. The popularity of Elliott YR single-stage turbines, in sizes from 2 to 600 hp, is also due to simplified design features which provide easy installation and easy access for routine inspection and maintenance. Five of these design features are illustrated here. The Elliott design also permits interchangeability of components from one turbine frame to another.

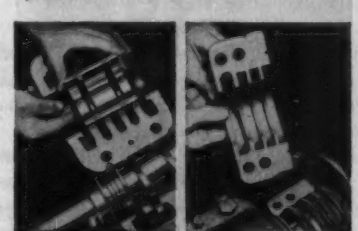
Other types of Elliott mechanical drive turbines are available, in sizes up to 20,000 hp. And when it comes to application engineering or maintenance assistance, your local Elliott field engineer is always available. For complete details write Elliott Company, Steam Turbine Department, Jeannette, Pa. Ask for Bulletin H-22B.

ELLIOTT Company

True Centerline Support assures accurate shaft alignment over entire range of operating temperatures, extends life of bearings of turbine and driven machines.



Weather-Proofed, Reliable Speed-Governing System maintains effective steam seal for long operating periods. Separate overspeed trip gives positive overspeed protection.



Liner Type Bearings (left) are sealed against elements, permit rapid heat transfer to cooling oil, are easy to inspect or replace.

Accessible Shaft Seal Covers (right) are easy to remove for inspection or ring replacement.

For more data on advertised products, use Readers' Service Cards, last page.

has full legal effect as to one of the parties, but is not enforcable against the other party against his will.

An **"unenforceable"** contract is one that meets the four requirements or essentials of a valid contract but, for some reason, may not be enforced by the court.

Thus, a refinery business contract arises out of a voluntary agreement between you and the other party. The obligations imposed by the contract are "self-imposed" since the parties "freely" entered into the contract.

A Valid Contract. If you don't already know, you might find it interesting to learn that a legal, enforceable contract consists of the following elements:

1. Mutual Assent. This involves an offer, a communication of the offer, an acceptance of the terms of the offer, and a communication of the acceptance. Sometimes the courts say that mutual assent means a "meeting of minds." And this "meeting of minds" must be voluntarily arrived at. The bargain or agreement between you and the other party must not have resulted from fraud, duress, undue influence, or mistake.

2. Capacity to Contract. You and the other party must have had a legal capacity to contract. If you and the other party have no such capacity, a contract will not result even though mutual assent exists.

3. Consideration. There must be "legal" consideration in every agreement, if a contract is to result. Every contract is an agreement, but not every agreement is a contract. We make many agreements daily in business. The reason for this is that many agreements do not create legal obligations. For example, an agreement to attend a convention of petroleum industry executives with someone is an agreement, but it is not a contract. The agreement does not create a legal obligation. It creates only a social obligation. The reason why the agreement does not contain legal obligation—and hence, a contract—is that it does not contain what is known as consideration.

While many people in business often think that consideration means the giving or payment of money, this is not true. The payment of money, however, will constitute "valuable" consideration, but this is not the only method of giving consideration.

SEASONED EXPERIENCE AND EXPANDED FACILITIES

. . . Try Bird-Archer Water Treatment Service

This is a corner of Bird-Archer's new laboratory in Philadelphia where speed and capacity to run tests of water samples has been doubled. Additional facilities and field personnel extend the benefits of Bird-Archer's popular 8-Point Water Treatment Service over a greater area than ever before. This program includes services helpful to you if you are not already a Bird-Archer client.

8 POINT WATER TREATMENT SERVICE for Power, Process and Cooling

1. Study of Water Availability and Supply
2. Survey of Plant and Process
3. Scientific Laboratory Analysis of Samples
4. Development of Treatment and Control System
5. Custom Formulation of Chemicals
6. Recommendations and Specifications for Equipment
7. Instruction of Plant Staff in System Application
8. Periodic Check-Ups by Field Service Engineers.

60 years' reputation for the highest quality chemicals and sound engineering in water treatment are your insurance in your investment in Bird-Archer service. Let a Bird-Archer man "trouble-shoot" your problems in water and steam control. Write for a copy of our free book, "Industrial Water Treatment" and the name of our nearest representative.

BA601

SEND FOR THIS CATALOG ALSO

BIRD-ARCHER
WATER TREATING ENGINEERS
THE BIRD-ARCHER COMPANY, 4337 N. AMERICAN ST., PHILADELPHIA 40, PA
New York, Chicago
The Bird-Archer Co. of California, 415 Brannan St., San Francisco 5
Offices also in Canada and Mexico

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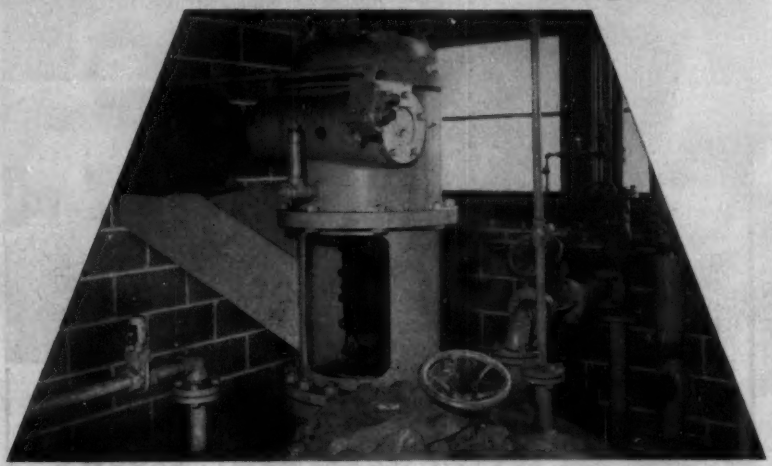
GET TOP PRODUCTIVITY FROM MINIMUM POWER CONSUMPTION

. . . with NETTCO Engineered Agitation!



ELIMINATE UNSATISFACTORY AGITATION, high power costs, and excessive maintenance with Nettco "process-rated" agitators. Standardized components (motor, drive, shaft, stirrer) can be combined to meet your exact size, speed, HP, and other process specifications. Check these Model T features . . .

- Minimum moving parts in compact, fully enclosed housing
- Interchangeable ratios from 6.25:1 to 100:1
- Dust, fume, and moisture-proof
- Complete range of speeds
- Anti-friction bearings throughout, quiet operation
- Splash lubrication — oil trapped against leakage
- Large diameter "stepped" vertical shaft
- Widely spaced, oversized Timken bearings

Model WT units (worm gear reduction drives) offer ratios from 3.5:1 to 68:1 and can also be "processed-rated" to your specifications for greater savings and dependable, uninterrupted service. Ask Nettco agitation engineers for recommendations. Request Bulletin 551 and data sheet from **New England Tank & Tower Company, 81 Tileston Street, Everett 49, Mass.**

NETTCO
ENGINEERED AGITATION

FREE LITERATURE

Please send me the following literature:

☐ Tank Top Agitators—Bulletin 551
☐ Portable & Tripod Mixers—Spec. Sheets
☐ Pipeline-Flomix®—Bulletin 531
☐ Side Entering—Bulletin 532

"Legal" consideration is found in the mutual promises of the parties if they surrender a legal right by making the promise.

For instance, A and B have an automobile accident and the negligence of A was the cause of the accident. B threatens to sue A. So, A says that if B will not file suit he will pay B for the damages done to his car. B agrees and does not file suit. Later for some reason A refuses to pay B, as promised. In such a case, consideration is found in the mutual promises of A and B. B purchased A's promise to pay by agreement not to sue A. B gave up a legal right to sue A because he had a legal right to sue in a court of law.

4. Legality of Subject Matter. Even though the minds of the parties have met, the parties have legal capacity to contract, and consideration exists, still a contract will not arise unless the final element—legality of subject matter—is met.

Let's take a simple illustration to clarify this. A promises B $100 if he will assault C. B agrees to do so and actually asaults C. Then B sues A for $100, alleging a contract not fulfilled. B cannot collect since the "objective" or the subject-matter of the agreement, a crime, is illegal. But if all four of these elements exists, a contract exists.

Contracts in Writing. Not all contracts can be enforced. The law provides that "certain" types of contracts must be in "writing" to be enforceable. Below are the types of contracts that must be in "writing" to be enforceable:

1. Contracts of executors and administrators who become personally bound for the debts of the estates that they are administering.

2. Contracts in consideration of marriage, such as pre-nuptial agreements.

3. Contracts to answer for the debt, default, or miscarriage of another. For example, A tells B to sell some petroleum products to C and agrees that if C does not pay, he (A) will pay the bill. This promise of A's must be in writing to be enforced.

4. Contracts involving the sale of real estate.

5. Agreements that may not be performed personally within one year. For example, if A orally agrees to employ B as a refinery engineer on May 1, 1958, work to start on

For more data on advertised products, use Readers' Service Cards, last page.

we make stainless steel valves ...nothing else

ALOYCO 111 Gate Valve for 150 lb. service features double disc ball-and-socket wedges. They are free to rotate and are non-fouling in any position which insures tight closure. There are Aloyco valves and alloys designed for every type of corrosive service.

SPECIALIZATION! Isn't it reasonable to believe that the one company with experience, facilities, research and service all devoted to a single product is your best source of supply? The modern Aloyco foundry, for example, is designed to produce one end product only: pressure-tight Stainless Steel Valve castings of the finest quality.

ALLOY STEEL PRODUCTS COMPANY
LINDEN, NEW JERSEY

Longer Lasting
ALOYCO
VALVES
1ST IN CORROSIVE SERVICE

Yes, Virginia, gasoline does cost less than it did 30 years ago. (Before taxes, of course.) Most oilmen know this story; we know how the power in regular gasoline has climbed from 50 octane in the mid '20s to over 90 today. We know, too, what a fantastic value gasoline represents as a commodity. An industrial worker labored 23 minutes to buy a gallon in 1926; today he works just 6½ minutes for a better product. *We* know—but the public does not. What are *you* doing to tell them? **SHELL OIL COMPANY**

SHELL

May 5, 1958, neither party could enforce the agreement, because it could not be performed within one year from the date it was made.

6. Agreements to sell personal property above a certain amount, usually $50, unless there has been part payment or part delivery.

Now you can clearly see that to make a business contract, certain legal "tests" must be met. In short, there must be mutual agreement between you and the other party, voluntarily arrived at. You and the other party must have had a legal capacity to contract at the time you entered into the agreement. The agreement must be supported by a valid or legal consideration; and, the subject matter or purposes of the contract must also be legal.

Rights. Are you aware that only the parties to a contract have any rights or duties under the contract? However, all rights under a contract may be assigned, without the consent of the other party, unless the contract is made non-assignable by its terms.

If, however, disagreement arises, and the controversy goes to court, the court will still have to decide whether a contract actually exists, and, if a contract does exist, what the rights and duties of the parties are under the contract.

Other Considerations. Obviously, you should keep a copy of every refinery business contract you sign. Without a genuine copy, you may have a difficult time proving what the contract involved when you signed it.

Before you enter into any business contract you should be sure that it is entirely clear and understandable. It should contain all the details which are intended to govern the refinery transaction.

Don't make business contracts unless you are willing to assume the outcome, and don't sign any contracts unless you know exactly what you are signing.

To protect yourself, and to be absolutely safe, have all your refinery business contracts examined by a competent attorney.

In so doing you will be better able to handle your refinery business matters more efficiently and economically without racking your brains about the legal pitfalls surrounding contracts. ##

MAKE ORDINARY EQUIPMENT CORROSION PROOF

KEL-F* LAMINATE offers a way to make any equipment and piping extremely resistant to acids, alkalies, oxidants, and solvents at temperatures up to 350°F—and at reasonable cost.

It is readily cemented over any contour and to any material of construction—metal, wood, concrete, etc. Also, KEL-F, being a thermoplastic resin, seams may be heat-fused into a continuous, chemically impregnable lining which is durable, shatterproof and abrasion resistant.

KEL-F Laminate, Garlock Style No. 9574, is available for installation by certified applicators, trained and equipped to assure best results.

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses in the U.S. and Canada, or write for Bulletin AD-152.

*Minn. Mining & Mfg. Co. Trademark

United States Gasket

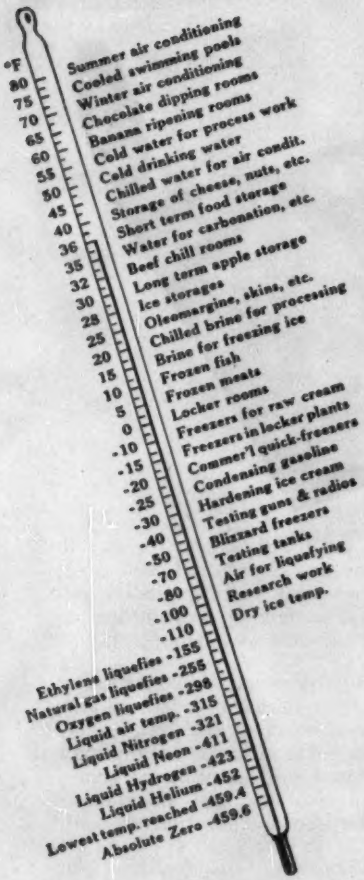
UNITED STATES GASKET COMPANY
Camden 1, New Jersey

Plastics Division of GARLOCK

DO YOU NEED REFRIGERATION?

TRADE FRICK MARK®

IS THE ANSWER



Frick Company designs and manufactures equipment engineered to your individual plant requirements.

IF YOU NEED ANY TYPE OF COMMERCIAL OR INDUSTRIAL COOLING . . . call your nearest Frick Branch or Distributor for recommendations and estimates.

DEPENDABLE REFRIGERATION SINCE 1882

FRICK CO.

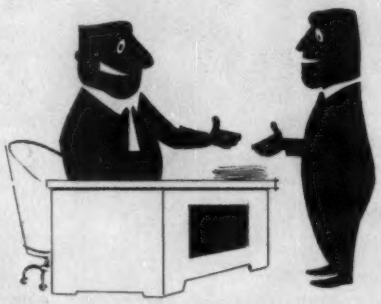
WAYNESBORO, PENNA., U. S. A.

As Management Sees It . . .

How Well Do You Handle New Employes?

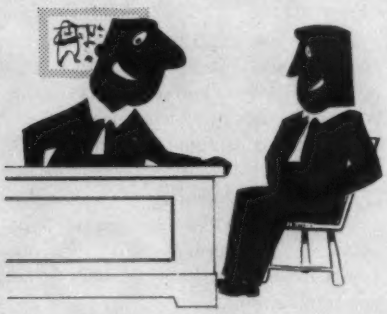
The time and effort required to set-up a good orientation program will go a long way toward boosting employe morale in the years to follow.

STUDIES SHOW that if a new engineer is going to change companies he will do it within the first year or two. A well planned orientation training program can help offset this migration.



It is highly desirable for new employes to know about the refinery, its services or products and its policies. They should have a clear understanding, too, of the rules and customs. They should know what is expected of them. In return they should understand what they can expect from the company. Their working hours, their wages, their opportunities for advancement should be mapped out for them.

A goodly portion of the orientation training should have to do with explaining employe benefits. And no orientation program is complete without showing the new employe a layout of the company facilities. By supplying the above information in a well planned orientation training program, the new employe will begin his career feeling that he is a part of the organization.



Purpose of Orientation. The primary purpose of any orientation training program should be to help the new employe get off on the right foot. It will develop confidence and give relief to that well known "first day's tension." A new employe wants to feel that he "belongs." An orientation training program will show him that

for plastics and resins:

90 plants

20 products

1 builder

Blaw-Knox, pioneer in the industry, sets the pace in designing and building plants for polymer and resinous compound production.

Blaw-Knox has led for twenty-five years in plant development for products ranging from condensation polymers such as alkyds and polyesters to addition polymers including synthetic rubber, polyvinyl chloride and polyvinyl acetate. Blaw-Knox construction parallels the mushrooming growth of the industry.

Blaw-Knox unexcelled know-how will pay off on your next project. A complete service is available—from preliminary planning to initial operation. Contact Blaw-Knox for details.

BLAW-KNOX

BLAW-KNOX COMPANY

Chemical Plants Division • Pittsburgh 22, Pa. • Chicago 1, Ill.

Birmingham • New York • Philadelphia • San Francisco • Washington, D.C.

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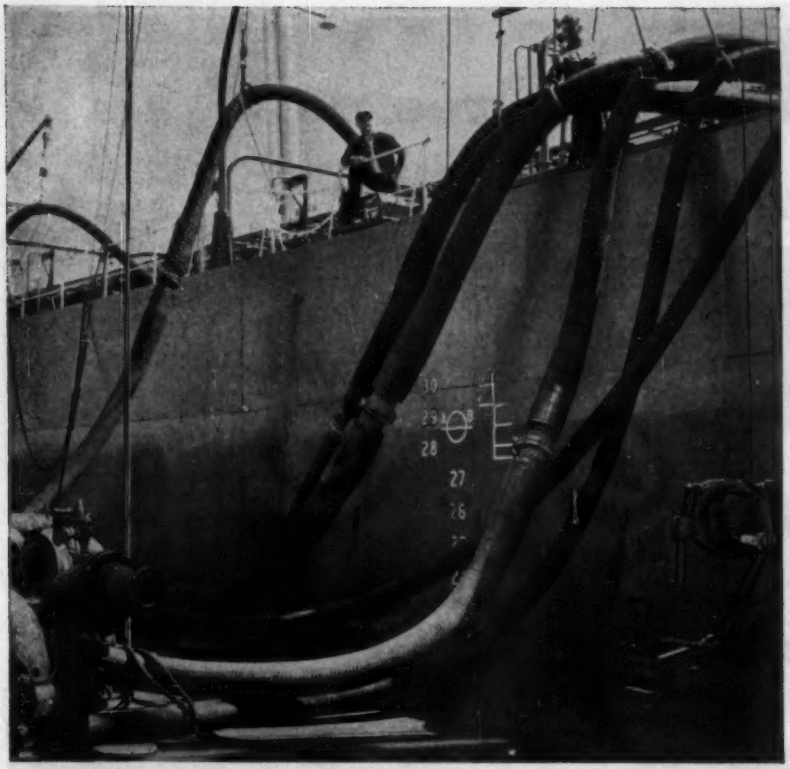


Unloading tanker with Quaker Qua-Flex Oil Suction and Discharge Hose.

Quaker oil transportation hose is 20% LIGHTER THAN COTTON DUCK WITHOUT SACRIFICING STRENGTH

Imagine an oil-tanker transfer hose every bit as sturdy and flexible as reinforced cotton-duck hose, but 20% lighter in weight! Quaker Qua-Flex Oil Suction and Discharge Hose satisfies those specifications, and more.

It's exceptionally kink- and crush-resistant. It won't expand under pressure. And it won't collapse under suction. The secret lies in Quaker Qua-Flex construction: separate layers of nylon tire cord surround a helix of high-tensile spring-steel wire to make Qua-Flex strong, but light . . . extremely rugged, but flexible.

For more details, call your local Quaker distributor, or write today to *Quaker Rubber Division, H. K. Porter Company, Inc.; Philadelphia 24, Pa., or Pittsburg, Calif.*

Nylon tire cord for lightness, strength.

H. K. PORTER COMPANY, INC.

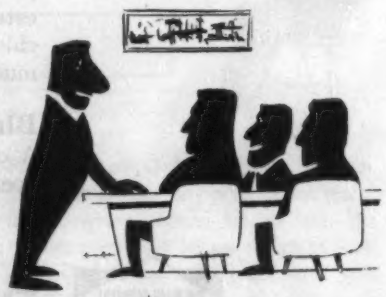
QUAKER RUBBER DIVISION

the company is interested in him as an individual and will treat him fairly. He will see relationships of the various departments and will recognize the avenues for advancement.

Before Hiring. Some of the orientation of a new employe is done before he is even hired. Good or bad impressions of the company are formed during the hiring process. Poor interviewing techniques, prolonged waiting and other irritating situations may create bad impressions that can linger for some time.

It cannot be emphasized too much, then, that the orientation training program be developed in conjuction with the employment office of the company. The personality and friendliness of the interviewer can do much to instill good first impressions of the company.

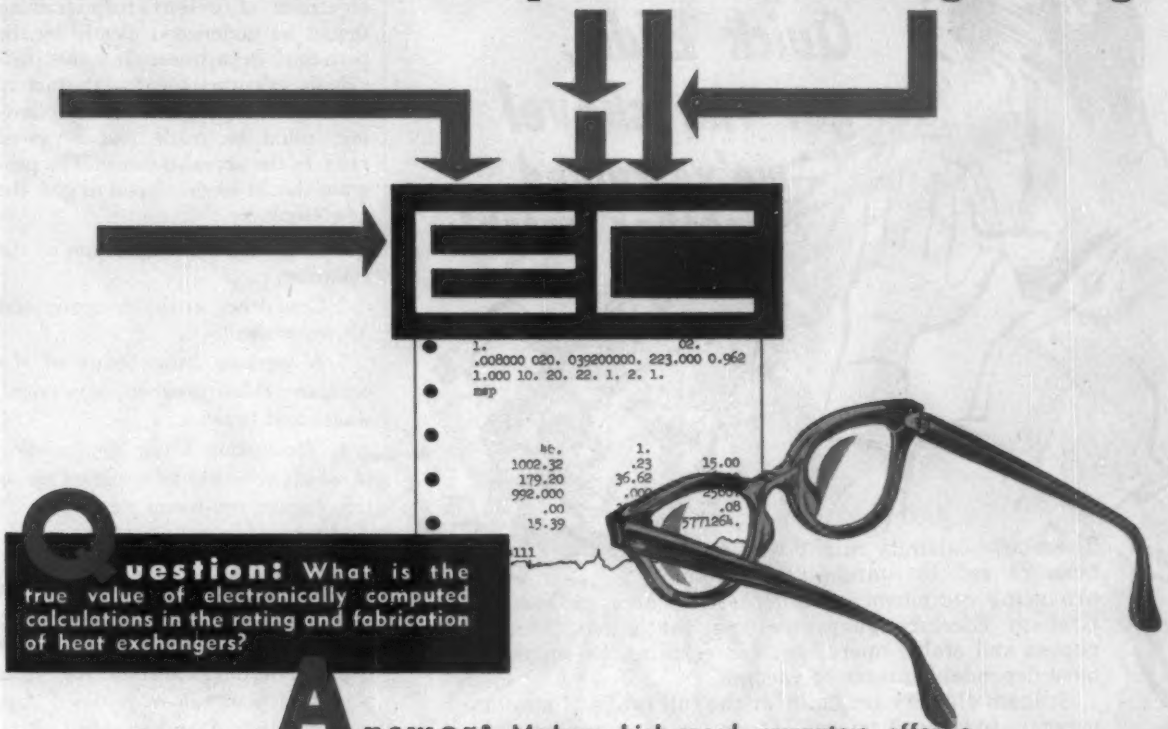
One precaution. There is some danger in giving the prospective employe more information at hiring time than he can digest. Give him only the essentials at that time. The important thing is for him to know that the company has thought of everything which will make his job and his future fair and promising.



Objectives of the Orientation program. Whether informal or formal, the program should be well planned

For more data on advertised products, use Readers' Service Cards, last page.

What about Electronic Computers in heat exchanger ratings?



Question: What is the true value of electronically computed calculations in the rating and fabrication of heat exchangers?

Answer: Modern, high-speed computers offer a high degree of accuracy, and enable a fabricator to carry a high volume of design ratings, HOWEVER . . .

. . . AT WESTERN, we recognize that, accurate as our electronically computed data is, the *effectiveness* of Western heat exchanger ratings depends on the *interpretations* our rating engineers put on the data. Thus personal scrutiny, years of experience with our customers and intimate knowledge of customer preference — all work together to produce the equipment you require *for your specific need.*

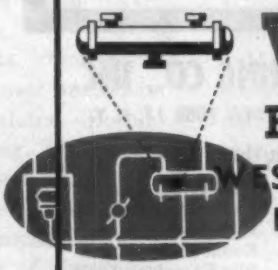
In the utilization of electronically computed data, a prescribed course is followed and should be thoroughly understood by both fabricator and customer.

First, the thermal and mechanical information is given by the customer. Second, preliminary calculations are made to set up the average physical and chemical properties of the fluids involved.

Third, the thermal and mechanical data is fed into the high-speed computer which is programmed to follow the step-by-step exchanger calculation procedures. Fourth, the electronic computer prints out the calculated answer to the problem.

Fifth — and MOST IMPORTANT AT WESTERN — each resulting rating is carefully scrutinized by our engineers in view of their extensive experience in the heat exchanger industry, as well as their background in customer preference. For years, Western has recognized that the true value of our electronic computer depends not only on the accuracy of the original data, but upon the precise and pertinent interpretations of the ultimate ratings by Western engineers, in light of each customer's specific application.

Proper utilization of the most modern methods is augmented by attention to detail and close personal relationship between Western and every customer, regardless of his requirements.



WESTERN
HEAT EXCHANGERS
WESTERN SUPPLY COMPANY
P. O. Box 1888 – Tulsa, Oklahoma

For more data on advertised products, use Readers' Service Cards, last page.

Quick Eddie, get the shovel —we've ruined another batch!

The above calamity might well have been caused by unreliable vacuum producing equipment — *and there's where we come in.* Graham Ejectors guarantee you continuous, uninterrupted and stable operation; for certain, it's industry's most dependable source of vacuum.

Graham ejectors are built for the full range of absolute pressure to below 1 micron, either steam or gas actuated, and we believe that further exploration will indicate additional progress.

Our standard ejector equipment may be shipped from stock. However, we always enjoy tackling a problem where special designs are involved.

Graham triple element three stage ejector for a refinery vacuum unit.

Graham MANUFACTURING CO., INC.

415 LEXINGTON AVE., NEW YORK 17, N. Y.

Factory trained engineers are available in these cities:

Baltimore, Md.	Detroit, Mich.	Philadelphia, Pa.
Birmingham, Ala.	Hato Rey, Puerto Rico	Pittsburgh, Pa.
Boston, Mass.	Havana, Cuba	Richmond, Va.
Buffalo, N. Y.	Houston, Tex.	Roanoke, Va.
Chicago, Ill.	Kansas City, Mo.	San Francisco, Calif.
Cincinnati, O.	Los Angeles, Calif.	Seattle, Wash.
Cleveland, O.	Mexico D.F., Mexico	St. Louis, Mo.
Coral Gables, Fla.	Minneapolis, Minn.	Toronto, Ont.
Denver, Colo.	Mobile, Ala.	Tulsa, Okla.

around some basic objectives. The objectives of orientation training should be understood clearly by the personnel department and the individuals responsible for the actual training. A list, similar to the following, could be made and reviewed prior to the actual training. The program should be developed to give the new employe:

1. A good initial impression of the company.
2. Confidence in the company and his department.
3. A working knowledge of the company rules, products or services, wages and benefits.
4. Information about the building in which he works as to eating facilities, storage, rest rooms etc.
5. An introduction to his job.

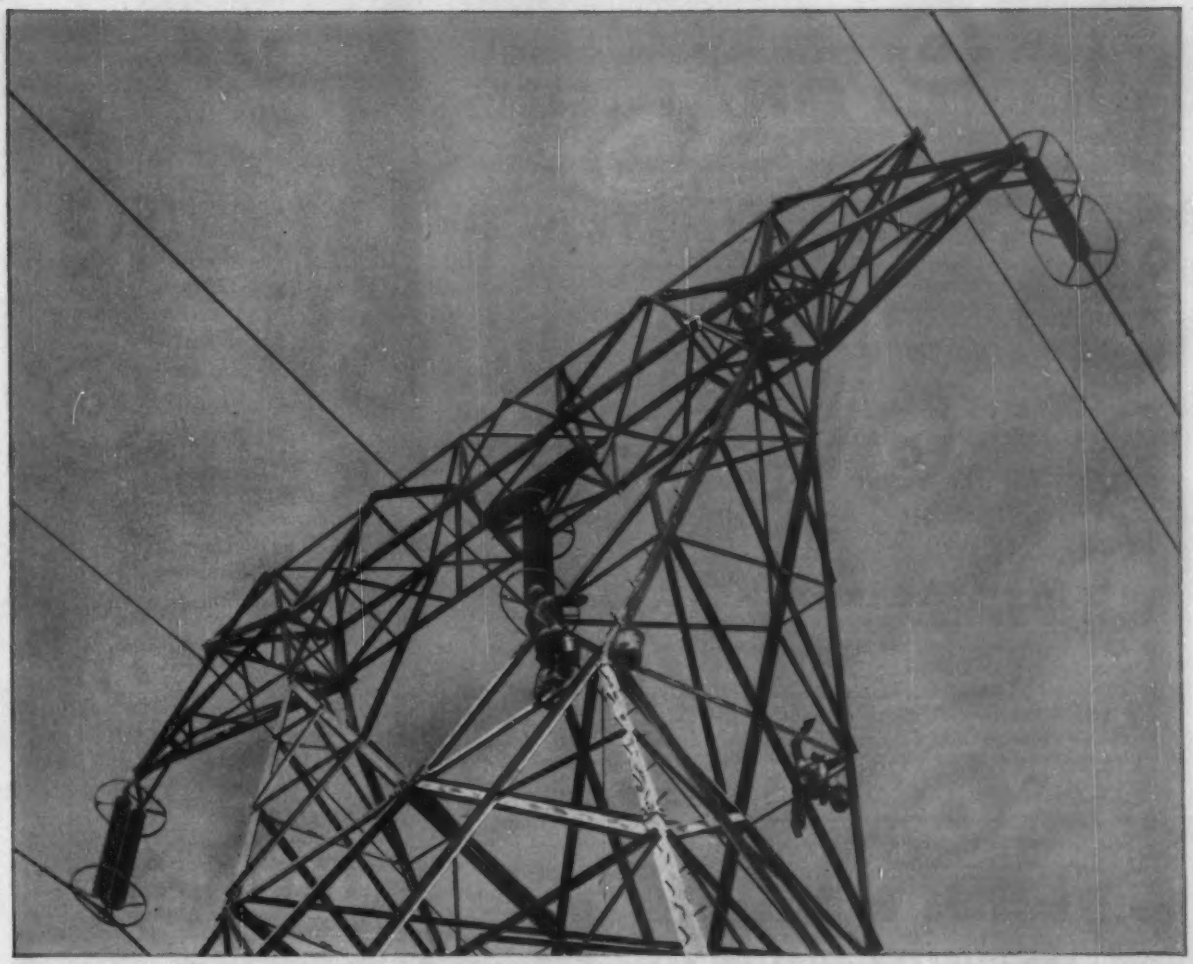
Accomplishing the Objectives. The procedures for accomplishing the above objectives will vary as needs and circumstances dictate. However, a general plan can be outlined that can be adjusted and modified to fit a particular company. One thing should be kept in mind, however. The practice of guiding the new employe in making his adjustments to his new environment is as serious a business as providing benefits for his future. The new employe needs moorings—something to tie to—and, without them, he is adrift.

A partial list of subjects to be included in the orientation is the following:

I. Information about the company
   - A. Objectives and functions
   - B. Company history
   - C. Number of employes
   - D. Organizational chart and key management
   - E. Physical layout
   - F. Company's attitude toward employes

II. Conditions of employment
   - A. Pay determination
   - B. Pay days, deductions
   - C. Working hours
   - D. Performance rating
   - E. Conduct—obligations and prohibitions
   - F. Personnel programs

For more data on advertised products, use Readers' Service Cards, last page.



How much does it cost to paint a tower?

That's a difficult question to answer, for much depends upon the size of the tower, and its location. But whatever the figure, it adds up to a major expense when rust-drip from tower bolts makes premature painting necessary.

It's now possible to obtain bolts which resist corrosion even longer than the tower members. These bolts are coated with Bethalume—Bethlehem's new hot-dip aluminum coating. Their cost? Just slightly more than ordinary tower bolts.

The Bethalume coating enables fasteners to resist corrosive atmospheres because it arms the base steel with a durable, uniform layer of aluminum. The coating is applied by the hot-dip process, and in equal thicknesses, outlasts ordinary protective coatings in practically every corrosive atmosphere. What's more, the coated threads are relatively clean and smooth-fitting.

If you would like to know more about Bethalume-coated fasteners, and how they can hold your painting costs to the minimum, just get in touch with the nearest Bethlehem office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

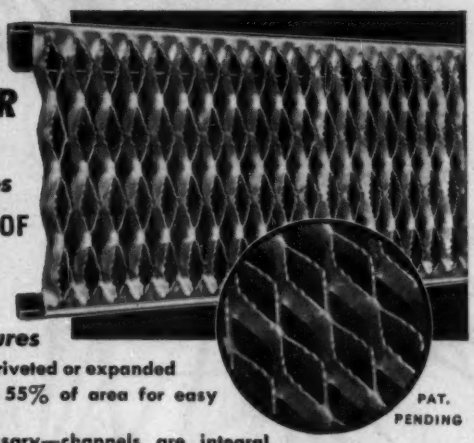
BETHLEHEM STEEL

For more data on advertised products, use Readers' Service Cards, last page.

two superior open steel
FLOOR GRATINGS
BY GLOBE

1 Safety GRIP-STRUT®

FOR MAXIMUM SAFETY ALL OVER YOUR PLANT



Important Safety Features

★ FIRE PROOF ★ SLIP PROOF
★ MAXIMUM STRENGTH
★ MINIMUM WEIGHT

Important Economy Features

★ All one piece, not welded, riveted or expanded
★ Open space in excess of 55% of area for easy access of light and air
★ No extra supports necessary—channels are integral part of the material. ★ Self cleaning
★ Cut and installed like lumber by your own maintenance force. ★ Low in original cost. ★ For balconies, no secondary sprinkler heads needed

Ideal for work platforms, stair and ladder steps, flooring, balconies, catwalks, machinery guards, fire escapes and for original equipment safety treads.

2 GOLD NUGGET® WELDED grating PAT. PENDING

The QUALITY GRATING for Heavy Duty Applications

★ 3/8" projection weld nugget for greater rigidity and strength
★ Vertical alignment of the main load bar assured
★ All bars are load carrying bars including secondary bars
★ Anti-skid pattern

PROJECTION WELD

Each secondary load bar (A), as projected welded to the primary load bar (B) has a shear strength of 5,000 pounds per weld. There are 28 such projection welds to a square foot of grating. This means that GOLD NUGGET Welded Grating can sustain greater shock loads than other gratings.

10,000 POUNDS

For the complete details of these revolutionary new gratings, write for new catalogs today. Distributors in all principal cities. Consult the yellow pages in your phone book under "GRATING".

108

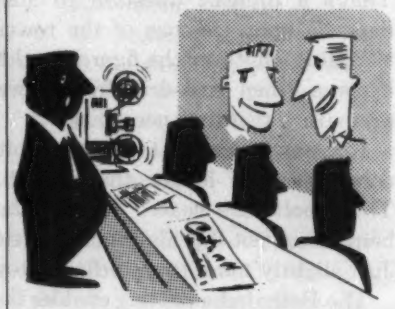
PRODUCTS DIVISION
The GLOBE Company MANUFACTURERS SINCE 1914
4008 SOUTH PRINCETON AVENUE • CHICAGO 9, ILLINOIS

III. Employe benefits and services
- A. Retirement
- B. Credit Union
- C. First aid facilities
- D. Hospitalization and insurance
- E. Recreational facilities
- F. Company publication
- G. Company organizations

IV. Job and work environment
- A. How employe's department fits into total organization
- B. Lines of communication and authority
- C. Layout of departments
- D. Special conditions of employment
- E. Leave, hours, lunch and rest periods
- F. Location of bulletin boards
- G. Introduction to work place
- H. Introduction to supervisor employes
- I. Job training arrangements

This list, one should note, is concerned only with information that the new employe needs. It does not cover the highly essential intangible aspects of orientation. These include an obvious spirit of welcome and good will, and a company attitude of interest and cooperation that may help develop a similar attitude in the new employe.

When the number of the new employes being hired each day is not too great, the orientation may be on an individual basis. The instructor should be picked carefully and well trained. A poor orientation instructor can ruin an otherwise well planned and important program.



Use the Group Method. Group methods of orientation are used not only when the numbers of new employes are so great that orientation cannot be individualized, but also as

Formula to sweeten a gaseous giant!

...feed it to a gas-scrubbing unit and let the laws of equilibrium take their course. Tremendous volumes of natural or refinery gas can be freed of hydrogen sulfide or carbon dioxide as Jefferson Ethanolamine does its work over and over again.

For *any* application, Jefferson Ethanolamines are available in the purity and volume you need—backed by excellent service from modern production facilities. **Jefferson Chemical Company, Inc., 1121 Walker Avenue, Houston 2, Texas.**

Mono-, Di- and Triethanolamine are available in tank cars of four to ten thousand gallon capacity, in tank wagons, and in 55-gallon drums.

Jefferson CHEMICAL COMPANY, INC.

Essential Chemicals from Hydrocarbon Sources

HOUSTON • NEW YORK • CHICAGO • CLEVELAND • CHARLOTTE • LOS ANGELES

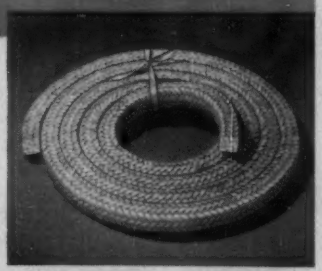
Ethylene Oxide,
Glycols, Dichloride
Ethanolamines
Morpholine
Piperazine
Polyethylene Glycols
Nonyl Phenol
Surfonic®
Surface-Active Agents
Ethylene Carbonate
and Propylene Carbonate
Caustic Potash
Caustic Soda
Soda Ash
Sodium Bicarbonate

For more data on advertised products, use Readers' Service Cards, last page.

How will you have your TEFLON packing

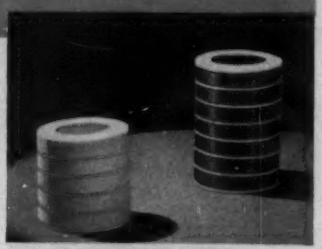
BELMONT TEFLON* Packings—impervious to acids, caustics, oxidants, solvents, for long troublefree life in the most difficult service—are offered in a wide variety of forms to best suit each individual requirement. Select your needs from the *most complete line* and get *exactly* what you want. Your Belmont Packing Distributor is ready to serve you. Or write for Catalog T-57.

BRAIDED



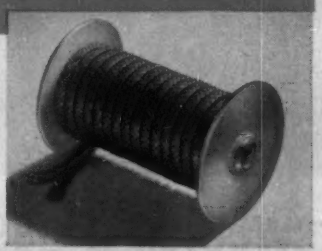
Belmont braided Teflon yarn (No. 3085) and Teflon ribbon (No. 3055) are offered with the rugged mechanical structure of Belmont's unique CRISS-CROSS Braid that will not ravel, wear through, slough off. Each strand criss-crosses diagonally through the body of the packing, becoming an integral part of the whole. Supplied in coil, reel and ring form.

MOLDED



Belmont Pump Packing Rings, molded from shredded pure Teflon with Teflon suspensoid (No. 3062) and impregnated with graphite (No. 3061) serve the requirements for both non-contaminating and general purpose chemical pump service throughout the processing industries. Supplied in sets with solid Teflon spacers.

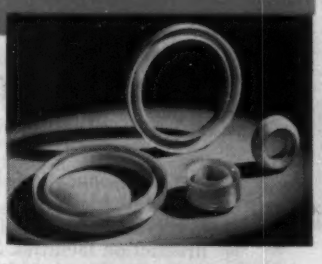
EXTRUDED



Belmont Extruded Teflon Packing (No. 3060-C) is shredded pure Teflon, impregnated with graphite and reinforced with a skeleton jacket of Teflon yarn. Available in reels and continuous lengths.

Belmont Bulk Packing (No. 3060-B) is shredded pure Teflon with graphite. Available in ½, 1 and 5-lb cans.

SOLID Rings



Belmont Solid Teflon Packings are offered in 3 designs—V-Rings (No. 3105), cup and cone (No. 3115) and wedge type (No. 3115-X). All provide a tight seal at low gland pressure and minimum friction on valve stem. Offered in sets, with square end adaptors where required.

*du Pont Trademark

The Belmont Packing and Rubber Company • Butler & Sepviva Sts., Phila. 37, Pa.

BELMONT

a part of formal orientation programs.

There are several reasons for extending new employe orientation beyond the initial introduction to the company by the use of group meetings. One of the laws of learning contends that more information is retained when it is given in small portions rather than in large doses. New employes cannot absorb all the information they need to know if an attempt were to be made to give all the information to them at once.

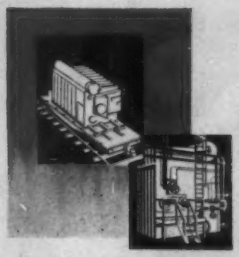
A lapse of time between the actual starting-to-work date and later orientation gives employes an opportunity to become used to some phases of their job and the company so that they can better understand the additional orientation they receive. In addition, orientation training scheduled for a few days or weeks after employes are on the jobs helps to show them that they have not been forgotten.

Group meetings also have the advantage of bringing employes together. This permits the new employe to meet others who are in the same situation. This tends to ease any feeling of loneliness that he may feel. At these meetings the new employe begins to feel as a member of a group.

In addition, group meetings save time by reaching a number of people at one time. This grouping also permits the head of the company, or the local manager, to meet and greet all the new employes. He probably would not have time for this highly important phase of orientation if he had to meet each one individually. Likewise, the program can include short talks by department heads about the functions of their respective departments and how they fit in with the organization. Special films can also be shown in group meetings.

The training given at group meetings will vary according to the makeup of the group. In a small company where only 10 or 20 new employes are hired every six months or so, a single comprehensive program can be given.

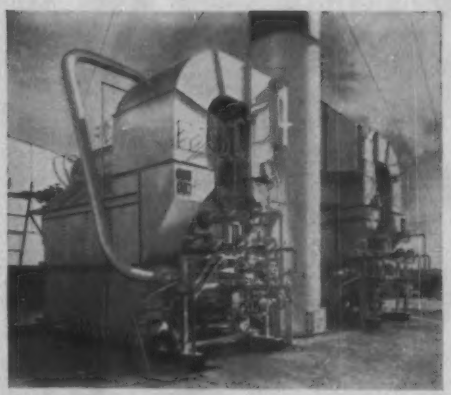
However, where there are enough new employes from different sections of the company, they may be divided into more or less homogeneous groups. This will change the agenda of the orientation program because the groups should receive different kinds



HEAT ENGINEERING by FW

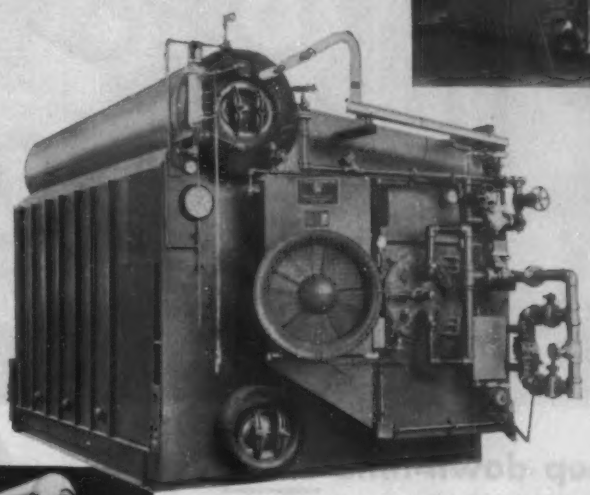
extends Central Station Reliability to Standard INDUSTRIAL and PACKAGED UNITS

PACKAGED STEAM GENERATORS of the water-tube type were introduced by Foster Wheeler in 1940 — combining in a single, compact, shop-assembled unit, all the necessary facilities for the dependable and economical generation of industrial steam. Continual research and development have resulted in further improvements in design and construction, and today the FW line of Packaged Steam Generators, in capacities from 10,000 to 60,000 lb/hr, represents the last word in modern steam plant design, reflecting over half a century of service to the power generation industry. Features include 36″ steam drum and 24″ water drum, staggered boiler tubes, closely spaced waterwall tubes, water-cooled target wall, and wide choice of burners and controls. For further details, send for Bulletin PG-55-3.

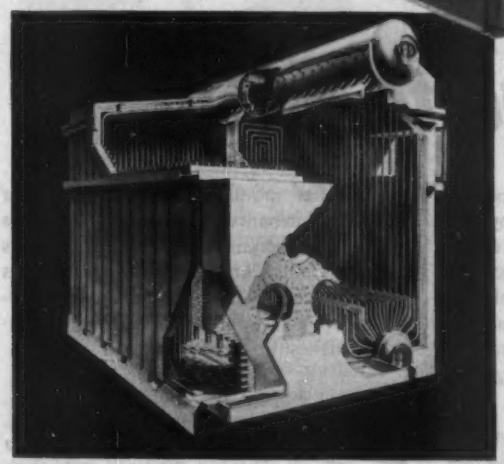


Above: Two FW packaged boilers — the first ever offered to industry — were installed for oil field drilling operations in 1940. They are still in service, delivering low-cost steam.

Left: New Foster Wheeler series AG-100 Packaged Steam Generator.



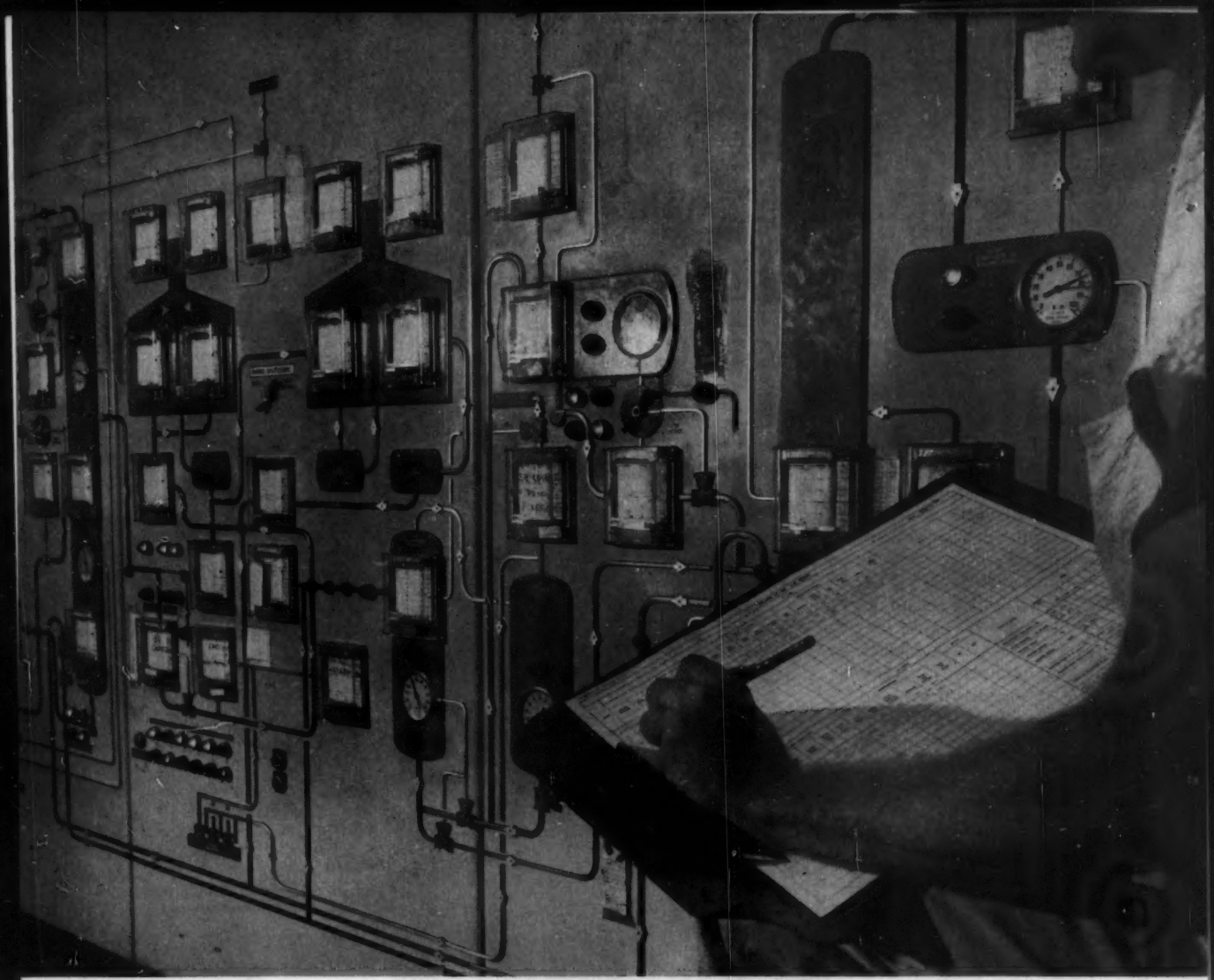
Cutaway view of typical FW Standard Steam Generator.



STANDARD PRE-ENGINEERED UNITS by Foster Wheeler offer all the advantages and economies of *standardization* for larger industrial steam generators of from 50,000 lb/hr to 450,000 lb/hr capacity. The new FW line of "SC" and "SD" standard units is heat engineered to the same standards of dependability and performance which have made Foster Wheeler steam generators first choice in many of the leading central station plants throughout the country. Features include completely water cooled walls, efficient firing arrangement, fully drainable superheater, high steam purity, unrestricted circulation, pressure-tight construction and minimum refractory baffling. For further details, send for Bulletin B-55-4. *Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N. Y.*

FOSTER FW WHEELER

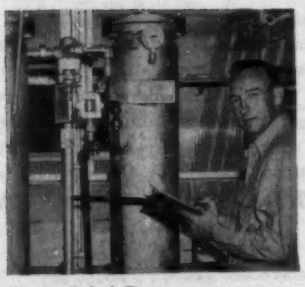
NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.



Typical Air-Operated Instrument Panel

To keep down-time down . . .

Come to Kemp



Kemp Oriad Dryer protects compressed air operated control instruments in Seaboard Oil's Powell, Wyoming plant. Dryer, operating 24 hours a day, seven days a week requires only routine maintenance.

A Kemp gas dryer in your operation can put an end to many costly shut-downs by protecting air-operated instruments from corrosion and freezing or jamming . . . efficiently drying inert gases for purging and blanketing . . . or drying atmospheres and process gases in hundreds of other applications. Operations are faster and safer, with better quality control and frequently reduced costs.

And Kemp dryers, operating on the dynamic drying principle, are noted for dependable operation. Rugged Kemp dryers will do your drying job around the clock, month after month, without stoppages or major maintenance. Kemp design reduces utility and operating costs, uses desiccants more efficiently, and eliminates process gas contamination. Units dry to lower dewpoints to give your processes and instruments highest possible protection.

Call your Kemp Representative, listed in the Chemical Engineering Catalog, for detailed information and a no-obligation survey of your dryer needs. Or write direct, for Bulletin D-100. The C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore 2, Md.

Kemp Convection Dryers

Kemp Inert Gas Generators

KEMP OF BALTIMORE

Kemp Industrial Carburetors

Kemp Oriad Dryers

or amounts of information. For example, there may be meetings for office employes and another for shop employes, for divisional employes and headquarters employes, for scientific employes and clerical employes. Scheduling these group meetings will depend upon the number of new employes reporting for work, arrangements being made when there are sufficient new employes to make up a group.

Other Orientation Ideas. Soon after, or during, the new employe's induction, a packet of booklets covering the orientation subjects should be given him. These booklets give the newcomer the information about his job, benefits and the company that he needs most.

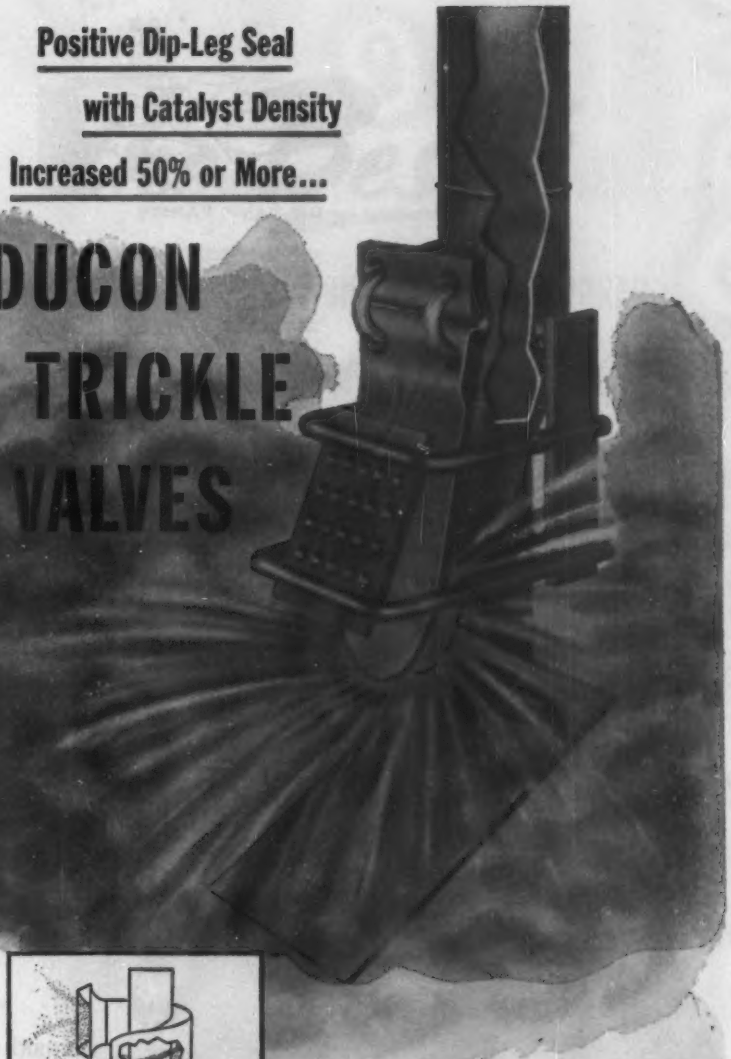
To rely on written material alone is not as effective, however, as to have a personnel department official discuss the subjects directly with the employe in an interview scheduled for some time after he has started work. This will permit the employe to ask questions about what he has read or any other matter that seems to confuse him.

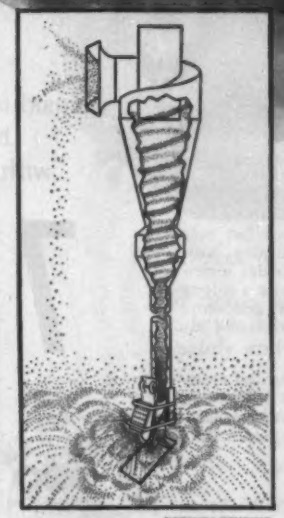
Evaluation. After developing a thorough orientation program and getting it off to a good start, one should not rest on his laurels. The success of the program can only be assumed unless some sort of followup is done. Such an investigation will reveal weaknesses that could not be ascertained during the development of the program. The facts gathered through the followup can be used to give additional information to the new employes which were not given in the original program, and they can be used to revise and modify future programs. The result should be more effective orientation training.

The new employe's supervisor is a key figure in the evaluation of the

Positive Dip-Leg Seal with Catalyst Density Increased 50% or More...

DUCON TRICKLE VALVES





PATENTS PENDING

Ducon Trickle Valves provide greater stability of cyclone operation by minimizing start-up and upset catalyst losses. Increased dip-leg seal catalyst density permits greater thru-put without additional dip-leg length and vessel height. With hundreds of Ducon Trickle Valves in service, the petroleum refinery industry itself has proved their unsurpassed dependability for continuous, trouble-free operation.

Write for details now on Ducon Type CA Trickle Valves—**the first dip-leg seals with approval for fluid catalytic cracking plants.**

Ask for Descriptive Bulletin No. CV-2506

DUCON

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THE Ducon COMPANY INC.

147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

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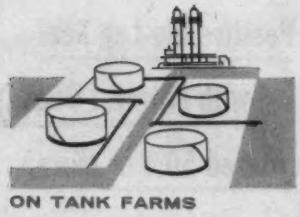
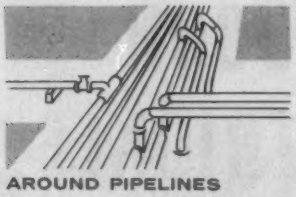


ON TANK FARMS



AROUND PIPELINES

AT WELL SITES

stop weeds and fires before they start

get preventive weed control with

GEIGY SIMAZINE* 50W

pre-emergence residual herbicide with

7 SAFETY FEATURES

Weed control is an old problem to the petroleum industry. Now Geigy's pre-emergence herbicide Simazine 50W provides a new and better solution — makes weed control *easier* because it is long residual; *safer* because of its Seven Safety Features; and *more effective* because it stops weeds before they start.

ONE APPLICATION PER SEASON

Simazine 50W reduces application costs in time, labor and material. At the rate of 10 lbs. per acre, one pre-emergence application controls annual grassy and broadleaf weeds for an entire season. At the rate of 20 lbs. per acre, one pre-emergence application controls most perennial weeds as well as annuals.

SEVEN SAFETY FEATURES

Oil maintenance men especially appreciate Simazine 50W's Seven Safety Features. This new herbicide is safe to humans and animals, non-flammable, non-corrosive, non-abrasive, and presents no conductivity problem or drift hazard. Check the panel for these and all of Simazine 50W's Seven Safety Features — and compare.

TECHNICAL SERVICE

Geigy Technical Service is readily available to serve you. Write for additional information, the name of your nearest Simazine 50W distributor, or ask to see a Geigy technical representative. Address: Geigy Agricultural Chemicals, P.O. Box, 430, Yonkers, N. Y.

1. **SAFETY TO HUMANS AND ANIMALS**
   Extremely low toxicity. No need for protective clothing.
2. **SAFETY TO ADJACENT VEGETATION**
   Minimum lateral leaching. Remains where it is applied.
3. **SAFETY TO SPRAYING EQUIPMENT**
   Non-corrosive or abrasive to equipment.
4. **SAFETY NEAR ELECTRICITY**
   Relatively low electrical conductivity.
5. **SAFETY FROM DRIFT HAZARD**
   Works through roots—little or no toxicity to foliage.
6. **SAFETY FROM FIRE HAZARD**
   Non-flammable. No application hazard.
7. **SAFETY ON VALUABLE LAND**
   Not a permanent soil sterilant.

200 years Geigy

ORIGINATORS OF Geigy DDT INSECTICIDES

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GEIGY AGRICULTURAL CHEMICALS • *Division of Geigy Chemical Corporation* • Saw Mill River Road, Ardsley, N. Y.

orientation program. He is the one who can best answer the questions about the effect of the program on the employes. Representatives of the personnel office or, better still, the training director, can obtain valuable information from supervisors in their day to day contacts or by special inquiry.

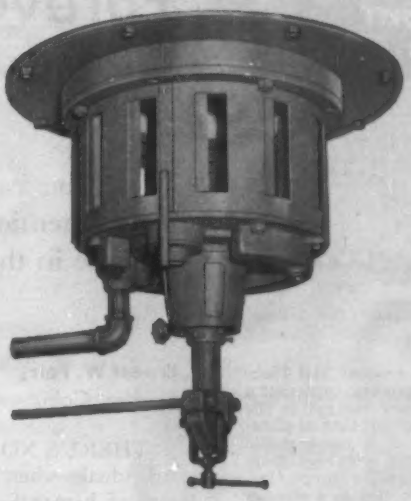
Another means of checking the effectiveness of the program is to arrange personal interviews with a sampling of the new employes. These interviews offer the interviewer an opportunity to find out how the employe feels about his job, how he is getting along, and to gather his criticisms of the orientation program.

If it is felt that the supervisor and/or employe will not answer frankly or supply any constructive suggestions during a personal interview, questionnaires can be used. They need not be signed by the participants. This will enhance the possibility of getting a true expression of the opinions as to the effectiveness of the orientation program and desirable revisions. These questionnaires can be filled out at the close of the group orientation meetings or at a later date when it is convenient. An unsigned questionnaire at the close of a group meeting can be very useful in evaluating how the meeting is "going over." How effective it is in truly orienting the employe cannot be determined, however, until the newcomer has been around for a period of time.

A company cannot gain loyal employes and public acceptance by interpreting hiring and induction as simply the process of putting workers on the payroll. But, the company that recognizes the fact that well planned training is important, financially and otherwise, can hope for real success in proclaiming its assets through a well planned orientation program.##

*the Best**

VERTICAL COMBINATION GAS & OIL BURNER



JOHN ZINK

series

"DA"

* Oil spillage cannot cause gas burner plugging.

If the oil can be pumped, the "DA" can burn it.

No matter what calorific value gas is made available, this burner can handle it safely and quietly.

For detailed information, write for Bulletin DA-357.

JOHN ZINK COMPANY

4401 SOUTH PEORIA TULSA 5, OKLAHOMA

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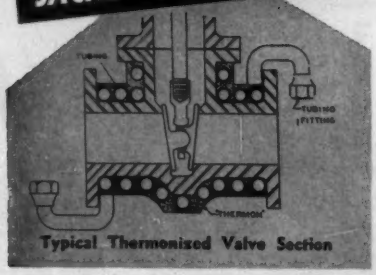
Thermon
The Revolutionary New Solid
HEAT TRANSFER MEDIUM
SAVINGS UP TO 75% over JACKETED EQUIPMENT



Typical Thermonized Valve Section

Thermon, the product, and Thermonizing, the process, represent a revolutionary new concept in the science of external heat application. Thermon is a non-metallic plastic compound with highly efficient heat transfer properties, and is easily applied in a viscous paste form over either steam traced or thermal electric systems. It completely surrounds the tracer tubing and conducts heat to the entire surface to be heated.

Definite Advantages of Thermonizing are:

1. LOW COST—save up to 75% over equal jacketed equipment.
2. EXCELLENT HEAT TRANSFER—Exceeds steam traced equipment approximately 1100% and very closely approaches jacketed equipment.
3. DEPENDABILITY—no hot or cold spots.
4. WIDE TEMPERATURE RANGE—used for sub-zero cooling or heating to 750°F.
5. NO JACKET PLUGGAGES OR PRODUCT CONTAMINATION—in case of equipment failure, Thermon separates product from heating medium.
6. GOOD MECHANICAL AND THERMAL SHOCK RESISTANCE—cracking, spalling, and degradation are all nil—less than 1% linear shrinkage.
7. ADAPTABLE—may be used with either steam traced or thermal electric equipment—installed at our shops or your job location.
8. RAPID DELIVERY—use of standard equipment permits minimum delivery time.

Write for comprehensive brochure about revolutionary Thermon!

THERMON MFG. CO.
1017 Rosine • P.O. Box 1961
Houston, Texas

You Can't Live Forever, But . . .

You can live longer and healthier if you give the same attention to your personal "machine" that you give to those in the refinery.

Ernest W. Fair,
Boulder, Colo.

"THERE'S NO more cantankerous individual—when it comes to taking care of himself—than the modern business or professional man," a doctor declared recently. "He'll rush the kids to the hospital on the slightest pretext and yell for the family doctor every time his wife looks tired—but take care of himself? He never does it until he's had a good scare at least once!"

Learning through the "good scare" route isn't wise. Far too often that incident turns out to be the actual end of the line.

"Accumulated nervous tension," another doctor warns, "damages more business men's constitutions than anything else I've noticed. Maybe it's the tempo of today's business or maybe it's something else, but one big thing is that we're not taking enough time to relax anymore."

Relaxing is more important than one may think at first reflection. It should be both mental and physical.

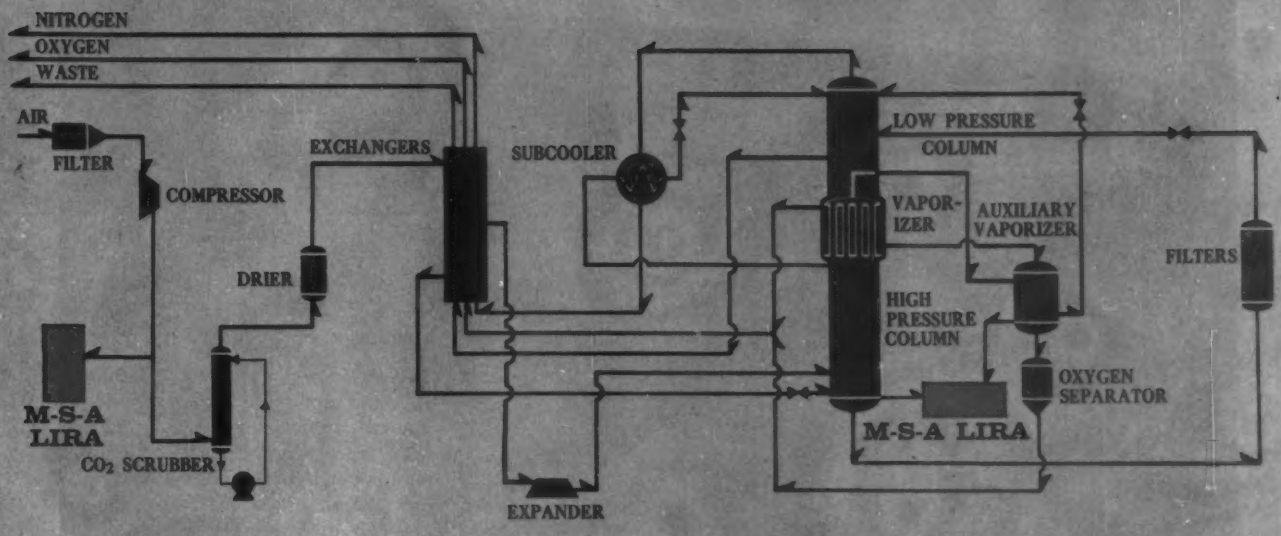
Not one executive in a hundred can go home from his office and forget his business without a powerful interest to completely dominate it. Ordinary pastime pursuits will provide interludes but not complete freedom. Going on day after day and night after night with concentration on a single theme can put some men on the "happy farm." For most, the result is broken health and inability to properly plan their business lives.

"We never hire a junior executive who hasn't learned to separate his business from his home life," the head of a large national organization says. "The executive who can approach his business with a fresh and alert mind every morning is the one who has left his business in the office the night before."

It takes top health to have the mental and physical energy to make intelligent decisions—it takes top health to be ready for the unexpected emergencies in the life of one's business—it takes top health to be the kind of business executive who inspires results from the people around him.

There are as many "systems" for guiding one's health as there are subparagraphs in a government regulation. Some are good and some are bad, but medical men generally will advise that "fads" and "easy-to-follow" schemes are generally not only worthless but—what is more important—dangerous!

There is no "magic formula" to good health for any executive. But there are a few steps that every one



Flow diagram of a standard medium pressure air separation cycle employing M-S-A LIRA Analyzers for plant safety.

Explosion-proof Model 200 has a tamper-proof lock, and all controls are easily accessible through the explosion-proof enclosure.

M-S-A® LIRA Analyzers can protect your oxygen plant

You can keep strict tabs on dangerous accumulations of acetylene and total hydrocarbons by continuously monitoring the air stream and the liquid pool with M-S-A LIRA Infra-Red Analyzers

Safe operation of air separation equipment demands continuous monitoring of acetylene. This troublesome hydrocarbon contaminant has very low solubility and is highly reactive. That's why a number of plants throughout the country are installing M-S-A LIRA Infra-Red Analyzers for explosion prevention.

These versatile instruments measure acetylene and total hydrocarbons in the air intake streams, as well as in the liquid pool itself. Model 100 LIRA Analyzers have been sensitized for full scale ranges of 1.0 and 2.0 ppm acetylene. Thus, it is possible to measure concentrations as low as 0.02 ppm acetylene. With this sensitivity it is also possible to continuously monitor the air stream and sound an alarm in the event a large concentration is suddenly drawn into the plant or, if there is a gradual build-up.

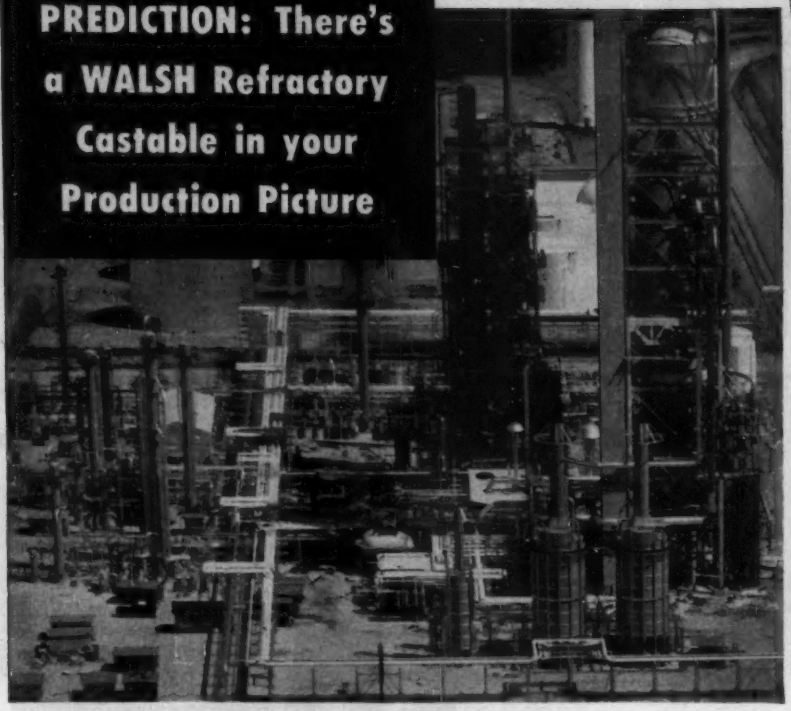
Model 200 Analyzers have been provided to measure the total hydrocarbons present in the air stream as well as the liquid oxygen pool. By means of these instruments, operators are advised at all times of the degree of contamination in the system, and can take steps to prevent development of explosive mixtures.

An M-S-A Instrument Specialist will be happy to discuss your product contamination problems. Write us for helpful literature.

INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

PREDICTION: There's a WALSH Refractory Castable in your Production Picture



Assurance Of New Highs In Performance At Lower Cost

Whether your refractory castable practice calls for a two-component lining or consideration of a "one shot" system later on—you'll find the right Walsh product for your purpose. Modern as tomorrow, every Walsh Castable offers absolute homogeneity—the result of production control methods that insure the perfect union of all ingredients for efficient service throughout a longer life. The whole money-saving story is available from your nearest Walsh representative. Or, write us direct, today.

WALSH EXTRA STRENGTH H & B CASTABLE (Service Type) For highly abrasion-resistant, monolithic, working linings in catalytic regenerators, reactors, and other refinery equipment.

WALSH LITE WATE INSULATING CASTABLE NO. 50. Features high bulk density while retaining a low K factor. Recommended for back-up use in two-component linings.

WALSH LITE WATE INSULATING CASTABLE NO. 70. Higher strength and a low K factor makes this insulating castable highly desirable for "one shot" linings.

All Walsh Castables are characterized by extreme "flowability", excellent nozzle compaction, lower rebound loss . . . plus greater strength, better bond . . . throughout the complete temperature range.

Send for New Illustrated Castable Bulletin

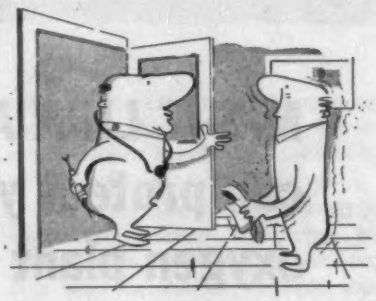
WALSH
REFRACTORIES CORPORATION
101 Ferry Street · St. Louis 7, Missouri
SPECIALISTS IN REFRACTORIES OF HIGH BULK DENSITY AND LOW POROSITY

can use. The results will offer no assurance of living forever but they will give a person more out of the life.

Those steps are as follows:

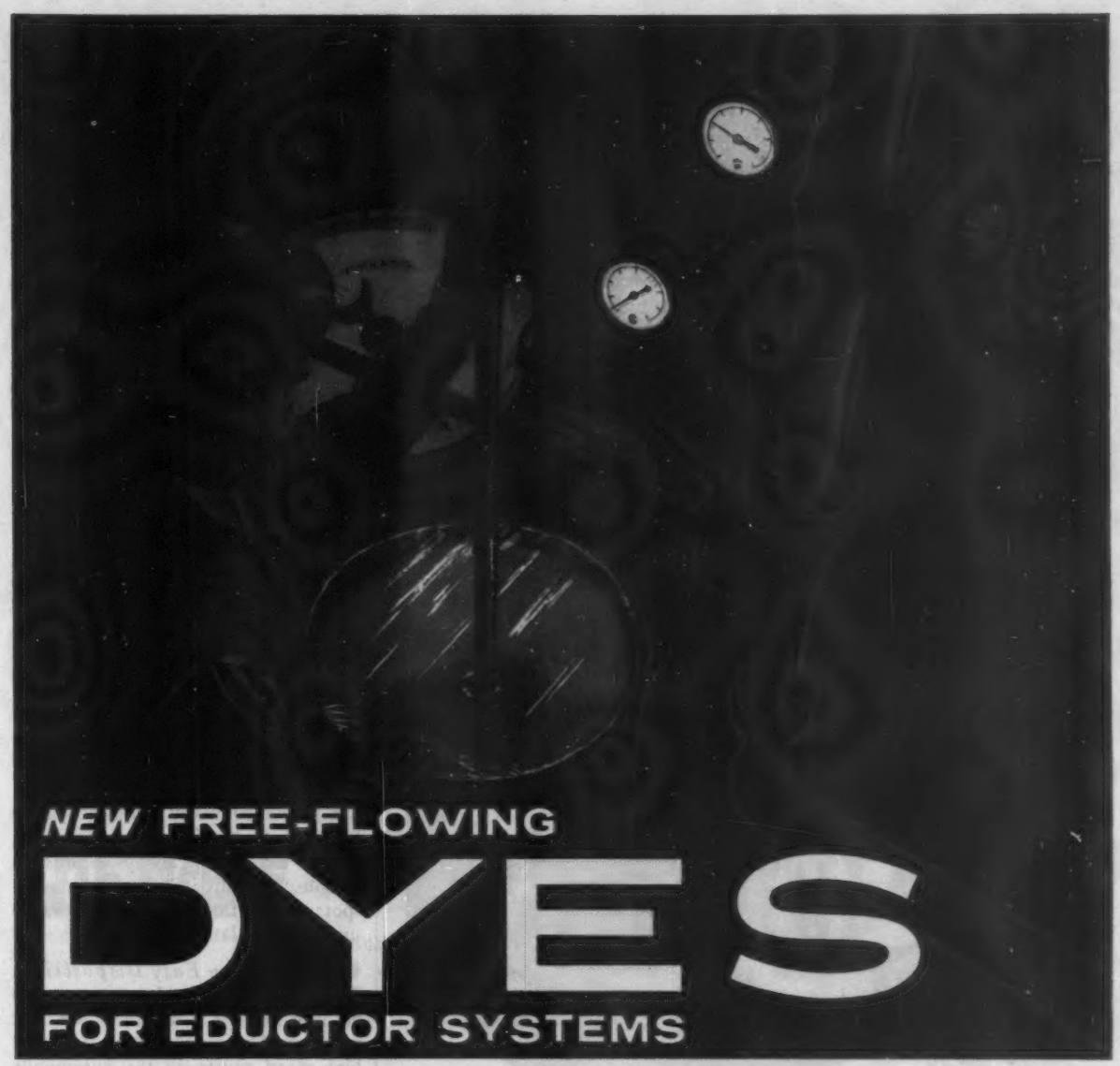
1. *Know Your Doctor as a Friend.* Too many of us look on the family doctor as the caretaker of our children and of our wives . . . never consider him our own caretaker and friend as well. The doctor's ability to help any of us depends on his knowing all about us *all of the time.*

2. *See the Family Doctor Regularly.* A check-up of one's physical and mental condition is just as important as a maintenance check-up on our equipment. The average life expectancy of all of us has leaped in the past twenty-five years because of the wonders of preventive medicine. None of these advantages can be ours if our doctor cannot discover the need for them early.



3. *Check Every Idea With the Family Doctor.* When we're feeling low, there's always someone ready to step forward with a sure-cure nostrum or a big health idea to solve our problem. Our wisest bet is to listen courteously and then check with the family doctor before we do anything. Some of those ideas may work well with the other fellow and not only be of no value whatever to us but they can be harmful.

4. *Relax—Mister—Relax!* We can run the motor in our car without rest for just so long, and it will start becoming sluggish, lose its power and demand attention from the "Motor Medic." the same thing holds true for the human body; its ability to keep going at top speed is good, but limited. Slow down, give every part of the body's machine a rest, and it will keep functioning at peak efficiency much longer.



NEW FREE-FLOWING

DYES

FOR EDUCTOR SYSTEMS

From coast to coast leading petroleum refineries look to the Koppers Company (formerly American Aniline Products) for the best in micro-fine dyes that will flow freely through modern eductor equipment. Available in a full range of brilliant shades, Koppers colors for the petroleum industry meet the most exacting refinery specifications for tinctorial strength and guaranteed lot-to-lot uniformity. New Vu-Dye Top on every drum prevents needless dusting, assures dry, lump-free dyestuff at all times, enables operator to watch level of drum contents as material is used. For working samples and technical assistance, consult our nearest branch.

YOURS FOR THE ASKING...
Valuable sample and laboratory evaluation kit with latest shade additions.

KOPPERS

Koppers Co., INC.

CHEMICALS & DYESTUFFS DIVISION

KOPPERS BUILDING, PITTSBURGH 19, PA. **Plants:** LOCK HAVEN, PA. **Branches:** Providence, R. I. • Philadelphia, Pa. • Paterson, N. J. • Chicago, Ill. Charlotte, N.C. • Chattanooga, Tenn. • Columbus, Ga. • Los Angeles, Cal. • Houston, Texas • **Dominion Anilines & Chemicals, Ltd.,** Toronto, Canada

Please rush FREE laboratory kit of Koppers Oil Colors to:

NAME.....

FIRM.....

POSITION.....

ADDRESS.....

Mail to Pittsburgh office or nearest branch. Our local representative is ready to provide full information and technical advice at any time.

For more data on advertised products, use Readers' Service Cards, last page.

5. *Follow Simple Health Rules.* Medicine has learned a lot in the past twenty years and all for our benefit; but unless we listen and put into practice these principles, all of this accumulated knowledge does no good whatever. Here's a suggestion: Insurance companies are vitally interested in our living as long as possible, so they have all sorts of very good literature on how to prolong life. All you have to do is ask your agent for it—and follow the simple rules of good health laid down in these booklets.

6. *Know the Danger Signs.* When that clatter-bang starts coming out of the family car, you know there's trouble in the engine and rush to a garage. When something goes wrong with a lot of us we reach for a pill and forget all about it until the next time. The clatter-bang is the car engine's warning of trouble—so is that out-of-ordinary clamor in our own physical make-up. It's no time for a pill; it's time to have a check with the family doctor and see what the warning is about so something can be done about it right now.

The great majority of cancer deaths can be avoided, we are told, if it can be spotted in first stages. So can nervous breakdowns, and a lot of other mental and physical ailments. We have a marvelous piece of machinery in the human body, and it's loaded with scores of safety valves and warning signals, if we but listen to the warnings when they occur.

7. *"Worry Gets Most Businessmen."* No matter how tough the problem, how large and hungry the wolf at one's doorstep, or how unsurmountable the latest tax problem appears . . . worry and fret about them will do no good.

"When I catch myself starting to worry about one of my business problems," an engineer commented recently, "I grab my hat and get out of the place as fast as I can—rush home, pack my fishing gear, and head for the nearest angling spot. The problem always waits for me, and when I come back I'm in much better shape to work it out because I didn't let worry completely overpower my ability to reason out the predicament."

8. *"We Can't All Be Henry Kaisers!"* Doctors say over-powering ambition has shortened many a businessman's life from five to twenty years. Trying to do too much always results in fatigue. The physical kind we readily spot; mental fatigue seldom shows up until it's too late.

9. *Develop an Easy Disposition.* That's a large order for many people because of the way they are put together. However, just as frequent high-speed spurts on the automobile engine are damaging; so are tempers, tantrums and fits of anger damaging to the body machine.

10. *Play the Health Odds as Close as You Play Poker Odds.* Few men would pay $100 in a poker game to draw two cards to an inside straight, but they will take on the same impossible odds with their health. Working late three nights in a row is such a procedure—taking on more than you can handle in the business world is another.

You can't live forever, but you can live much longer and enjoy it more fully, if you give the same attention to your personal "machine" as you do to those you use in your oil field operations. ##

WHY AIR COOLING FOR PROCESS INSTALLATIONS?

- No Scaling or Corrosion
- Trouble Free
- Low Maintenance

WHY SMITHCO PROCESS COOLERS?

- Metallically Bonded Fintube
- Experienced Engineering
- Heavy Duty Design
- Quality Manufacturing

It's a SMITHCO . . . Your Guarantee of Quality

SMITHCO Engineering Inc.

P. O. BOX 3217
TULSA, OKLAHOMA

For more data on advertised products, use Readers' Service Cards, last page.

THE NAME THAT MEANS QUALITY FITTINGS

In drilling, production, or refinery applications, Larkin quality fittings are installed with confidence. The many separate manufacturing and inspection phases are your guarantee that every Larkin fitting is built to exacting standards. Manufacturing know-how and years of experience means that **you get what you pay for** in Larkin fittings.

All Larkin products are available through your supply store.

Larkin Hexagonal Bull Plug

Larkin Hexagonal Swaged Nipple

Color coded for thread identification

Larkin Forged Steel Swaged Nipples

LARKIN PACKER COMPANY, INC.

WAXAHACHIE, TEXAS

LARKIN ...Through Your Supply Store

PESA

LARKIN LEADERSHIP HAS BEEN EARNED BY YEARS OF DEPENDABLE PERFORMANCE

General Chemical announces its

THIRD HF PLANT!

Now Nitro, W. Va. ③

① MARCUS HOOK, PA.

Make General Chemical your HQ for HF!

② BATON ROUGE, LA.

Construction is now underway for General Chemical's third hydrofluoric acid plant. Producing both aqueous and anhydrous acid, it will augment the company's already extensive HF capacity at Baton Rouge, La., and Marcus Hook, Pa.—and assure ample reserves to meet industry's needs for the foreseeable future.

Your Most Dependable Source of Supply for HF

General Chemical is the *only* supplier offering shipment from more than one producing location. In addition, it has five HF stock points at Buffalo, N. Y., Chicago, Ill., Cleveland, O., El Segundo, Calif. (Los Angeles), and Pittsburgh, Pa.

Also important to you is General Chemical's integrated raw materials position—your best protection against interruptions of supply. General owns and operates its own fluorspar mines and mills, and sulfuric acid plants. These, together with multiple, high-capacity HF plants, plus strict quality control all along the line, make *General* your most dependable source of supply for hydrofluoric acid.

First For Fluorine Chemicals

GENERAL CHEMICAL DIVISION

40 Rector Street, New York 6, N. Y.

Allied Chemical

Offices: Albany • Atlanta • Baltimore • Birmingham • Boston • Bridgeport • Buffalo • Charlotte • Chicago • Cleveland (Miss.) • Cleveland (Ohio) • Denver Detroit • Houston • Jacksonville • Kalamazoo • Los Angeles • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh • Portland (Ore.) • Providence San Francisco • St. Louis • Seattle • Kennewick, Vancouver and Yakima (Wash.) In Canada: The Nichols Chemical Co., Ltd. • Montreal • Toronto • Vancouver

If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

"If Oil Could Speak" it would tell the American public:

Are Oil Industry Employe Benefits as High as Other Industries?

The following answer speaks for itself: According to the U. S. Chamber of Commerce, the oil industry pays the highest average yearly salary—$5259! Welfare benefits cost the oil industry $1278 a year for each employe—the highest fringe benefits in U. S. industry. The oil refining industry alone must have a capital investment of $38,000 per employe. For all manufacturing industries, the average is $8600.

How Large Is the Pipe Line Industry?

Fifty-six years ago, the entire petroleum pipe line industry was made up of less than 18,000 miles of pipe lines—all of them for crude oil. Now there are more than 152,100 miles of crude, and 36,400 miles of products lines, equal to 85 percent of the rail line mileage in the U. S. Since 1949, more than 36,000 miles of pipe lines have been built, costing more than 1.5 billion dollars.

How Much Oil Is Produced, Compared With Other Natural Resources?

Total U. S. production in the past ten years is valued at 62 billion dollars—about equal to the total value of all other minerals, metals and fuels produced in the nation.

Is the Motorist's Gasoline Dollar Decreasing in Value?

Definitely not. Today's gasoline does 50 percent more useful work per gallon in a modern high compression engine than gasoline bought in 1925. In fact, one hour's pay is good for nine gallons of gasoline, compared with eight in 1952. In the past five years, gasoline prices have gone up a little more than four pennies per gallon. Of that increase—1½ pennies went for added taxes.

How Is Oil Transported to the Consumer?

More than 188,500 miles of petroleum pipe lines, 1500 barges, 490 tankers, 123,000 railway tank cars and 81,400 tank trucks are part of the mammoth transportation system that delivers more than 135 billion gallons of oil products to consumers every year—8.8 quarts daily for each man, woman and child in the nation.

To What Extent Does the U. S. Depend on Oil?

Machines, that depend on petroleum for virtually all their lubrication and almost three-quarters of their fuel, now do almost 99 percent of the work in this country. The weekly energy output of petroleum in the U. S. has been estimated to be around 40 hours work of more than 65 billion people—24 times the total population of the world.

Catawissa
PERFECT SEAL
Unions

HOT FORGED from solid, rectangular steel bars, designed and produced for dependable, long-life service under the severest piping conditions!

A TYPE FOR EVERY USE!
FOR ALL PRESSURES!
FOR ALL TEMPERATURES!

Standard & Double Extra Heavy
UNIONS
Available with screwed or socket weld ends. 3000-lb. sizes ⅛" to 3"; 6000-lb. sizes ⅛" to 2".

ORIFICE UNIONS
With screwed or socket weld ends. 3000-lb. and 6000-lb. service.

MALE & FEMALE UNIONS
With steel-to-steel, bronze-to-steel, stainless steel-to-steel or orifice seats. 3000-lb. service only.

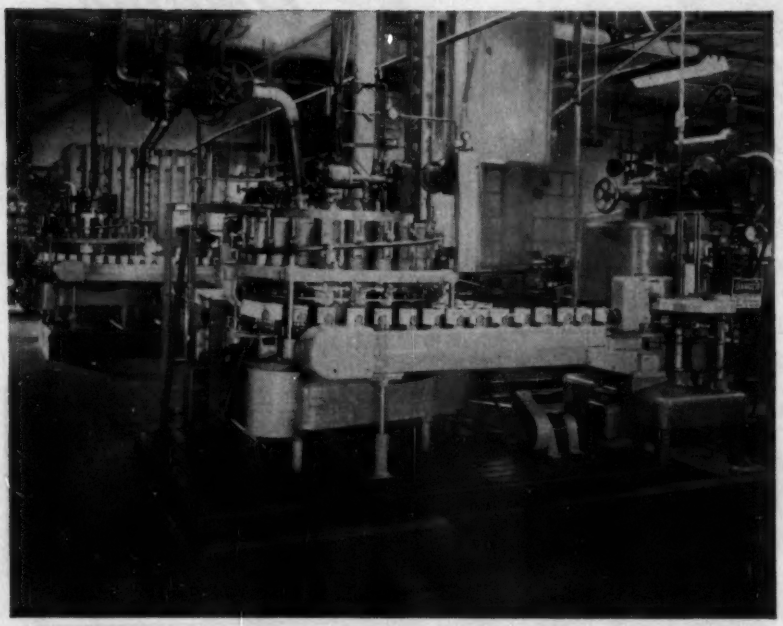
FULL STAINLESS & FULL ALLOY STEEL UNIONS
With screwed or socket weld ends. 3000-lb. and 8000-lb. service.

WRITE FOR CATALOG 56
showing the complete Catawissa line of Perfect Seal Products

CATAWISSA VALVE AND FITTINGS COMPANY
60 Mill Street • CATAWISSA, PA.

For more data on advertised products, use Readers' Service Cards, last page.

PFAUDLER

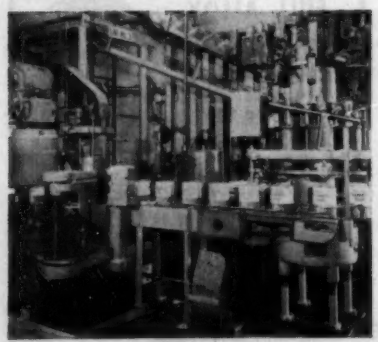


425 quarts a minute filled on this 21-station lube filler at Texaco plant. A total of three Pfaudler fillers handle all lube packaging requirements of the Port Arthur plant.

Filling without spilling at Texaco to 99.9969% accuracy

Texaco uses just three machines at its Port Arthur plant to fill a complete line of motor oils, hydromatic fluids, and antifreeze in quarts and gallons.

Two of these machines—RPL-21 type Pfaudler piston fillers—fill 410 to 425 quarts a minute. They each hold another 65 quarts a minute in reserve capacity. They fill at any viscosity over the complete temperature range 80° to 105° F.



The third machine — an RPL-7 Pfaudler filler — handles gallons at 60 to 80 per minute.

All three machines are accurate to ±0.1 ounce by liquid volume. They eliminate spillage completely . . . send cans from the plant with labels and cartons *clean*. No maintenance is required beyond routine cleaning.

There are only three primary wearing parts on these Pfaudler fillers: piston and valve rollers and valve trip cams. All are inexpensive and easy to replace. There are no connecting rods or wrist pins to cause trouble.

Simple, positive adjustments of the can support rails eliminate product spillage by compensating for the centrifugal forces generated during high-speed filling. An accelerating infeed screw pushes cans in uniformly without jamming.

Cleaning is easy, too. You empty the bowl through a drain port, flush with kerosene, put the machine through a few revolutions, and it's clean.

There's more information about the complete line of Pfaudler fillers offered in the coupon.

New flush valve boasts one-piece glassed head and stem

When we took all the porcelain out of this bottom outlet flush valve, we eliminated a major cause of valve failure.

Head and stem are *one piece and glassed*. No cement. The seat is made of rigidized Teflon-glass fiber and its bevel mates with that of the spherical head. Rubbing the glassed head on the Teflon seat produces absolutely no static. The Teflon also has some "give" so you can get a firm seating without danger of cracking the head covering, a continual problem with the old porcelain designs.

We don't have to tell you of the positive and leakproof sealing you

For more data on advertised products, use Readers' Service Cards, last page.

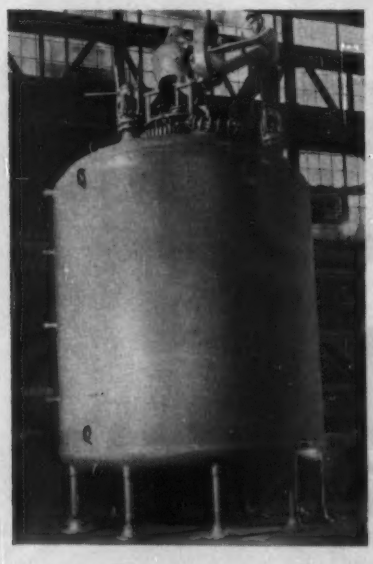
CORROSIONEERING NEWS

get with this ball-joint construction. And it's probably equally self-evident that the rounded, glassed head eliminates product build-up during processing.

So all there is left to tell is that the new design is interchangeable with existing valves you might now be using, and that the unit costs no more than a conventional stainless steel valve. Sizes range from 1½ by 1 to 8 by 6 in six different models.

Anything else you might want to know is covered in Data Sheet 42 which is offered in the coupon.

This is the most glassed-steel agitated reactor you've seen in one piece. O.D.: 120 inches. Height: 125 inches. Capacity: 7000 gallons. Material: glassed steel. It will be used to process monochloroacetic acid and alcohol at 158° F. The jacket is designed to take a 25 psi pressure at 350° F. This vessel uses a conventional three-blade impeller *without a foot bearing*. The agitator is set only 10 inches off bottom. *Moral:* We are ready to answer the most unusual process equipment requirements, and to glass any vessel from one-gallon lab units to giants like this. *For the record:* We've made vessels up to 35,000 gallon capacity for large volume storage and these are glassed, too!



130th Technical Course on maintenance and repair completed

Since we started our program of instructing maintenance and process men in the care and repair of glassed steel, more than 1800 men from more than 250 companies have graduated *cum laude*. The program started in 1941.

An interesting fact proves that these men and their companies have benefited from the instruction. Last year there was more than twice as much glassed-steel equipment in the field as in 1945. Yet we had far fewer units returned for factory repairs.

A goodly share of this improvement can be laid to the fact that we have improved our glass over the years as well as the design of the equipment and accessories. But much of the improvement must still be attributed to more effective preventive maintenance in the field and to more effective repairs made right in customer plants by customer personnel.

If you have some new men you'd like to take the course, either here in Rochester or near your own plant, please let us know. You can start by writing for a copy of the program describing the course's subject matter.

Check the coupon.

PETROLEUM EQUIPMENT by PFAUDLER

a division of PFAUDLER PERMUTIT INC., Dept. PR-38, Rochester 3, N.Y.

Please send information on ☐ Bltn. 878 RPL Oil Fillers; ☐ Bltn. 964 RPL-36 Oil Fillers; ☐ DS-42 Flush Outlet Valve; ☐ Maintenance Class Program; ☐ Bltn. 947 Buyer's Guide.

Name.....

Title.....

Company.....

Address.....

City.....Zone.....State.....

For more data on advertised products, use Readers' Service Cards, last page.

It's a fact...

Warren's Service Is Unsurpassed!

WARREN Resources of Production, Transportation and Storage, and WARREN'S Experience as a Specialist in its field assure you of complete and dependable DELIVERIES of . . .

NATURAL GASOLINE

whatever the grade and the volume!

WHERE, WHEN and the WAY you want it!

for QUALITY
QUANTITY
and SERVICE
Rely on . . .

WARREN

PETROLEUM CORPORATION

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What's Happening . . .

. . . in the Industry

New Chemical Facilities For 1958-59

Investment in production facilities for petrochemicals to be $242 million.

APPROXIMATELY $2.54 BILLION will be spent for domestic construction of new chemical production facilities in 1958 and 1959, the Manufacturing Chemists' Association has announced.

This estimate is based on the activities of companies comprising the chemical industry—already the nation's third largest in terms of assets—and the chemical operations of firms identified primarily with other fields.

The 1957-59 estimated total investment in production facilities for general organic chemicals maintains the number-one position in the classification by category. Total for organics: $987 million.

General inorganics at $710 million are in second place, followed by metals, $615 million; plastics and resins, $451 million; synthetic rubber, $298 million; petrochemicals, $242 million; fertilizer chemicals, $211 million; textile fibers, $161 million; laboratories, $107 million, and a miscellaneous group, $62 million.

The miscellaneous group covers expenditures difficult to classify in a more specific category, as well as confidential data from other categories. Only those fibers produced by chemical synthesis are included in the textile fibers grouping. Products produced for chemical use from petroleum and natural gas comprise the petrochemicals category.

The total figure, up slightly from the 1957-58 MCA survey estimate, includes 322 projects already begun and 119 projects scheduled for ground-breaking in the near future and completion before 1960.

Projects now underway will cost about $1.83 billion. The price tag on scheduled construction is estimated at $708 million.

According to results of the MCA's annual survey, chemical producers in 1957 completed 309 domestic construction projects at a total cost of $1.3 billion.

Combined estimated total on construction expenditures for the three-year period, 1957-59; a record $3.84 billion. This represents 750 projects by 344 companies in 400 communities of 42 states.

This figure does not include costs for general office, sales office, warehouse or other separate service facilities. Foreign construction and government-financed construction, too, are excluded.

Texas, ranking second behind New Jersey in chemical production, again is the recipient of the highest total investment for the three survey divisions of Planned Construction, Under Construction and Completed (1957) Construction. The Texas total: $864.5 million.

Louisiana is second with $494 million and West Virginia follows with $278 million. Others in the top 10 are Ohio, $228 million; California, $188.7 million; New Jersey, $155 million; Florida, $144.7 million; Tennessee, $127.6 million; Pennsylvania, $120 million, and Illinois, $119.5 million.

States ranking 11 through 20 are

MCA Chemical Industry 1957 Construction Survey by States

STATE	(BY THOUSANDS) Planned	Under Construction	Completed	TOTAL
Alabama	$ 1,500	$ 15,300	$ 14,325	$ 31,125
Arizona	.....	1,000	1,200	2,200
Arkansas	.....	5,570	750	6,320
California	36,850	75,640	76,196	188,686
Colorado	.....	15,125	5,008	20,133
Connecticut	1,000	11,116	3,620	15,736
Delaware	.....	3,000	1,200	4,200
Florida	2,375	57,850	84,550	144,875
Georgia	.....	17,000	44,900	61,900
Idaho	13,500	.....	.....	13,500
Illinois	24,000	47,538	47,956	119,494
Indiana	34,000	14,475	15,000	63,475
Iowa	.....	.....	1,000	1,000
Kansas	4,500	5,000	2,200	11,700
Kentucky	5,800	24,520	36,085	66,405
Louisiana	40,100	396,350	57,527	493,977
Maryland	.....	23,200	3,600	26,800
Massachusetts	650	16,200	11,550	28,400
Michigan	16,900	20,350	17,450	54,700
Minnesota	.....	400	26,000	26,400
Mississippi	.....	35,800	12,450	48,250
Missouri	11,000	13,500	14,500	39,000
Montana	200	.....	1,000	1,200
Nevada	.....	3,750	.....	3,750
New Jersey	24,325	59,200	71,440	154,965
New Mexico	20,575	25,500	20,600	66,675
New York	20,787	69,027	17,165	106,979
North Carolina	25,000	54,325	3,600	82,925
Ohio	26,300	86,950	114,850	228,100
Oklahoma	4,000	39,500	13,500	57,000
Oregon	.....	6,900	6,700	13,600
Pennsylvania	13,500	49,950	56,500	119,950
Rhode Island	150	.....	1,200	1,350
South Carolina	2,500	2,600	.....	5,100
Tennessee	24,500	50,100	53,000	127,600
Texas	137,750	354,330	372,700	864,780
Utah	25,000	12,000	10,750	47,750
Virginia	9,500	71,650	3,450	84,600
Washington	7,500	4,900	20,100	32,500
West Virginia	101,500	124,650	52,050	278,200
Wisconsin	500	150	40	690
Wyoming	14,500	7,000	4,500	26,000
Location Unspecified	57,800	13,750	2,100	73,650
TOTALS	$ 707,962	$1,835,166	$1,302,312	$3,845,440

What's Happening. . .

New York, Virginia, North Carolina, New Mexico, Kentucky, Indiana, Georgia, Oklahoma, Michigan and Mississippi.

Primary considerations in the location of chemical-producing facilities, according to the MCA, generally are the same as those for other industries —availability of raw materials and labor, proximity to prime markets and adequate transportation.

MCA Chemical Industry 1957 Construction Survey by Category

CATEGORY	(BY THOUSANDS) Planned	Under Construction	Completed	TOTAL
Fertilizer Chemicals	$ 45,575	$ 50,500	$ 114,800	$ 210,875
Inorganic Chemicals	99,000	350,935	260,586	710,521
Organic Chemicals	171,987	517,629	297,403	987,019
Metals	76,175	396,332	142,318	614,825
Petrochemicals	104,750	88,550	49,115	242,415
Plastics & Resins	151,500	101,820	198,120	451,440
Synthetic Rubber	18,050	145,230	134,500	297,780
Textile Fibers	.....	91,000	70,000	161,000
Laboratories	8,125	67,870	31,220	107,215
Miscellaneous	32,800	25,300	4,250	62,350
TOTALS	$707,962	$1,835,166	$1,302,312	$3,845,440

Regionally, the West South Central States—Arkansas, Louisiana, Texas and Oklahoma—lead in total construction for the 1957-59 period with a collective total of $1.4 billion. The South Atlantic States—Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia and Florida—rank second with $688 million. Third with $466 million are the East North Central States—Ohio, Indiana, Illinois, Michigan and Wisconsin.

Regions following are, in order, Middle Atlantic, East South Central, Pacific, Mountain, West North Central and New England. Construction not announced for specific areas accounts for $74 million.

The MCA announced that the metals category has been broadened in this survey to include zirconium, titanium, niobium (columbium), boron, tantalum, vanadium, beryllium, uranium, alumina and mercury. Excluded are copper, magnesium, aluminum, lead and zinc.

Removal from the over-all totals of expenditures for metal processing facilities included in the survey for the first time this years lowers, but does not negate, the record for combined expenditures estimated for the 1957-59 period.

Particularly significant is the estimated investment in research laboratory facilities. The three-year figure of $107 million includes $31 million for completed construction, $68 million for under construction and $8 million for planned construction.

The industry's total research expenditure, including operating and maintenance costs, currently is estimated at approximately $500 million a year.

The chemical industry long has maintained the highest growth rate

for peak heat exchanger efficiency . . .

HARTZELL'S NEW CONTROLLABLE PITCH FAN

The Hartzell Controllable Pitch Fan meets a long-standing need in the petroleum industry for a precise method of controlling a variable flow of air to maintain predetermined temperatures. On test installations, these new fans have proved their ability to hold outlet temperature fluctuation to plus or minus 1½°F. And, while achieving this highly accurate level of control, they consume up to 50% less power than required by conventional fixed-pitch fans.

In a temperature sensitive control system depending on air flow, the amount of air required to achieve the necessary cooling depends on the temperature of the air. High air temperatures require high air deliveries, low air temperatures require minimum air deliveries. With a Hartzell Controllable Pitch Fan, variable air delivery is accomplished by variation in blade pitch setting. The fan assembly responds instantly and automatically to conventional temperature sensitive control equipment — increasing blade pitch to deliver more air when outlet temperature rises, decreasing blade pitch and delivering less air when outlet temperature falls.

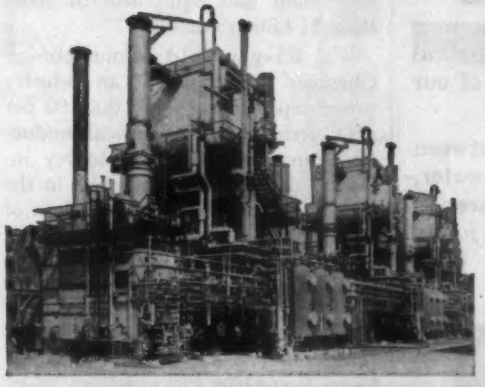
For complete details on Hartzell's controllable pitch heat exchanger fan, write for Bulletin 111-B or call your nearby Hartzell field engineer.

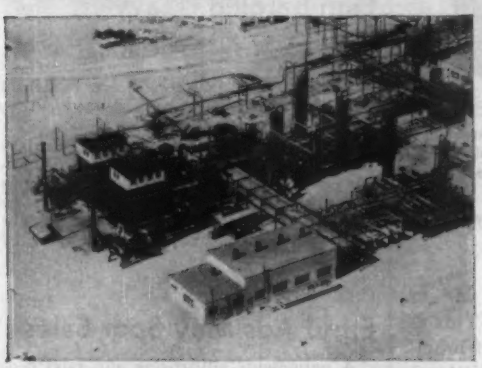
HARTZELL PROPELLER FAN CO.
Division of Castle Hills Corp.
71 Thomas Blvd. Piqua, Ohio

HYDROGEN

...how much do you need?

Girdler offers you complete engineering-construction service for BIG-CAPACITY *plants*





When you plan facilities for "tonnage hydrogen" for treatment of refinery feed stocks and hydrocarbon products, it will pay you to take advantage of Girdler experience.

Big plant experience: Girdler has designed and constructed large plants for petroleum products and chemicals. Two hydrogen plants have been built each of which can produce gas at the rate of seventy million cubic feet per day. More than 45 Girdler hydrogen plants are giving outstanding performance in the United States and Canada.

Girdler manufactures all of the catalysts used in Girdler hydrogen plants. These catalysts permit high production rates.

Call or write for complete information

GIRDLER

CONSTRUCTION DIVISION

NATIONAL CYLINDER GAS COMPANY

Louisville 1, Kentucky

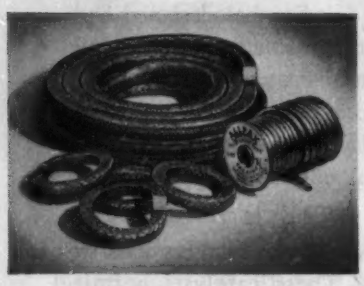
Sales Offices: New York, N. Y.; San Francisco, California

Engineering Offices: Louisville, Kentucky; Orlando, Florida

For more data on advertised products, use Readers' Service Cards, last page.

These two styles of Allpax Packing cover a wide range of applications and many different uses, consistent with the policy of our company—fewer packings for more services.

Both are compounded of the highest quality materials, and between them they cover against such service conditions as steam, water, air, ammonia, gases, oils, distillates, dowtherm, etc. They are for use on centrifugal and rotary pumps, valve stems, expansion joints and similar equipment.



Packaged in durable metal containers to insure protection and preservation of material. Applications and uses conveniently noted on each container.

Style No. 1 is really universal in its uses—where the temperature does not exceed 600 degrees F.

Style No. 2 also has an extremely wide variety of uses in higher temperatures, ranging from 600 degrees F. to 1200 degrees F. This is because of a special bonding compound, containing a heat-proof lubricant, which maintains the lubricant under high temperature conditions.

Both types are made in ring, spool or coil form in a wide variety of sizes. Allpax Packings do a better job for manufacturers and replacement use because they are precision-made, accurate in dimensions. They provide a tight seal without danger of scoring or unnecessary wear.

ALLPAX

"The Packing that Packs All"

SEND FOR OUR NEW CATALOG — TODAY!

A complete line of packing, tools, gasket materials.
Distributors in principal cities.

THE ALLPAX COMPANY, INC.
160 Jefferson Ave., Mamaroneck, N. Y.
CANADIAN DISTRIBUTORS: Albion Asbestos Packings Ltd., Montreal 8, Quebec

What's Happening. . .

for major manufacturing industries. Considered by many to be the most dynamic segment of the national economy, the industry early in 1957 moved into number-three asset position for all manufacturing. Total assets today: $19.6 billion.

For 12 consecutive years, chemicals and allied products—as they are listed in federal reports—have averaged a total capital investment for new plant and equipment of more than $1 billion annually.

The 85-year-old Manufacturing Chemists' Association is an industry group representing more than 90 per cent of the nation's chemical production capacity. Its annual survey includes all chemical companies in the U. S. and the chemical operations of firms more closely identified with other industries. Examples of the latter are the rubber and oil companies.

Lion Barging Heavy Fuel to New Orleans

Lion Oil Co. is shipping heavy fuel from its 30,000 bpd refinery at El Dorado, Ark., to New Orleans by barge.

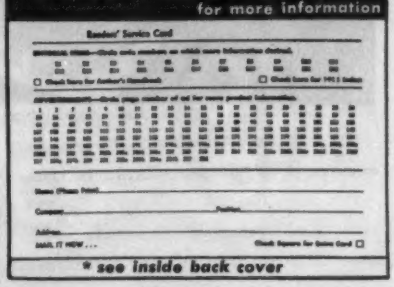
The first shipment was made February 13 from its docks at Champagnolle Landing on the Ouachita river. The product is trucked from Lion's plant to terminal storage on the river where the company plans to load two 15,000 barrel barges every 10 to 15 days.

Ethyl Ads May Spur Sales

A nationwide advertising and sales promotion program to help increase the sales of all products at the service station level has been launched by Ethyl Corp. Called the "Magic Circle," it is designed to stimulate motorists all over the country to drive more for pleasure.

The campaign marks the fourth consecutive year Ethyl has sponsored a market-

use these
READERS' SERVICE CARDS*
for more information



* see inside back cover

AT Sohio's Toledo, Ohio refinery the compact 200 hp Cooper-Bessemer EM compressor shown here supplies shop air at an exceptional saving: a saving in space, in maintenance costs and over all operating expense.

Offering such important design advancements, such as natural force balance, these M-Line units deliver smooth performance without vibration.
This installation is typical of the many important jobs being handled with dependable equipment furnished by Cooper-Bessemer.

Cooper-Bessemer packaged air compressors are available in four basic sizes from 200 to 10,000 hp. Write today for complete information.

WITH COOPER · BESSEMER

exceptional dependability and compactness

BRANCH OFFICES: Grove City • New York • Chicago
Washington • San Francisco • Los Angeles • Houston
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SUBSIDIARIES: COOPER-BESSEMER OF CANADA, LTD. . . .
Edmonton • Calgary • Toronto • Halifax
COOPER-BESSEMER INTERNATIONAL CORPORATION . . .
New York • Caracas • Mexico City

This two-cylinder Cooper-Bessemer air compressor, *with 5-step unloading, efficiently handles shop air requirements at Sohio's Toledo Refinery. Note the neat and compact appearance.*

Cooper/Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

expansion program on behalf of the oil industry.

The essence of the Magic Circle idea is that around everyone there's a magic circle of wonderful and interesting things to do and see by automobile. It may be a trip to a scenic or historic place; a week-end vacation or a long overdue trip to visit old friends. No matter where you are, the promotion will tell motorists, your car makes it possible to draw around yourself a magic circle filled with adventure, beauty and fun.

The Magic Circle promotion is based on studies which indicate that about one-half of the car-owning families in the United States rarely or seldom use their automobiles for pleasure or leisure driving. Changing this situation is a major objective of the campaign.

The campaign will be promoted in two separate but interrelated ways. One is through the Magic Circle Travel Clinic and the other by a series of color advertisements in magazines.

The Magic Circle Travel Clinic is a weekly news and feature service which is sent to some 200 newspapers throughout the U. S. on an exclusive basis by city. It is a complete weekly column to promote travel by car. Part of each issue contains a Magic Circle tour around a different city. Specially prepared maps or illustrations accompany each article. No mention of Ethyl Corp. or any product is made in this news service.

Petrofina Buys Atlas Corp's. Major Oil and Gas Holdings

Under a recent agreement American Petrofina, Inc., will acquire all of the major oil and gas holdings of Atlas Corp. The total price was not disclosed.

Involved in the transaction are all of the assets of the wholly-owned Atlas oil subsidiary, Petro-Atlas Corp., Tulsa, and its subsidiary Eldorado Refining Co., Eldorado, Kansas. These include about 11 million barrels of oil reserves, approximately 125 billion cubic feet of gas, the 20,000 barrel a day Eldorado oil refinery and some 500 petroleum marketing outlets. Petro-Atlas properties have a current daily production of about 3,000 barrels of oil and about 10 million cubic feet of gas.

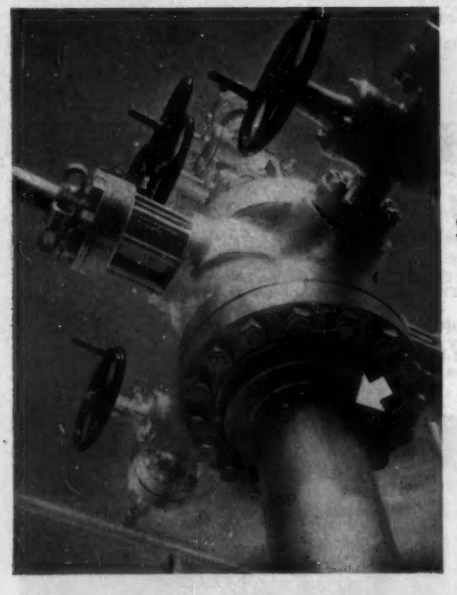
Sun, Fluor Work Together On Water Problems

Sun Oil Company, Philadelphia, and The Fluor Corporation, Ltd., Los Angeles, have announced an agreement under which Fluor will provide consulting engineering and related design and construction services for Sun's methods of industrial waste water management, including the newly-developed technique of biological oxidation in cooling tower systems.

The heart of the process consists of selective segregation of waste waters at their source, reduction of certain objectionable components, collection and storage of process and area drainage followed by reuse in conventional cooling tower

Weldynamics

ARC WELDING AT WORK CUTTING COSTS



. . . not just any electrode,

SHIELD-ARC 85 IS NEEDED HERE!

Shield-Arc 85's special high tensile strength (85,000 psi) makes it first choice for critical welds like this. . . . And its extremely easy operating characteristics—its freedom from pinholes cut welding time and *costs.*

An AWS E-7010 electrode, Shield-Arc 85 is fully described in the new Weldirectory, Bulletin 7000.1. Sent on request.

The World's Largest Manufacturer of Arc Welding Equipment

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systems where biological oxidation of the waste water is accomplished.

The return of water to the plant sharply reduces the water demand from outside sources and the application of cooling towers for bio-oxidation eliminates the need for construction and operation of costly conventional trickling filter or activated sludge equipment.

The resulting water conservation savings of up to 50 per cent of plant requirements represent a rapid economic return for the cost of the installation. In addition, the drainage collection and storage facilities for the process provide a dependable and virtually inexhaustible source of water for emergency fire protection.

API Meeting to Have International Flavor in '59

The midyear meeting of the Division of Refining of the American Petroleum Institute will have a particularly strong international flavor in 1959.

Dates for this big gathering of American technologists, scientists and manufacturing executives have been re-scheduled so that the API sessions will tie-in with the Fifth World Petroleum Congress.

Both meetings will be held in New York, the API Refining Division being scheduled for May 27-29, and the international congress May 31-June 6.

The Fifth World Petroleum Congress will be host to some 5,000 oil scientists and technologists from all over the world, in 1959, and invitations are being extended to these men to attend the API Refining meeting.

Oil men from as many as 45 different countries may be expected to participate in the API sessions. Twelve to fifteen technical sessions will be held during the API meeting, at which papers will be presented on such subjects as maintenance, corrosion, processes, waste disposal and other contemporary matters.

Pontiac to Buy Wilshire

Pontiac Western Corp., a subsidiary of Pontiac Western (Pontiac Refining) has completed arrangements for acquisition of Wilshire Oil Co. of Calif., and Wilshire Products Inc.

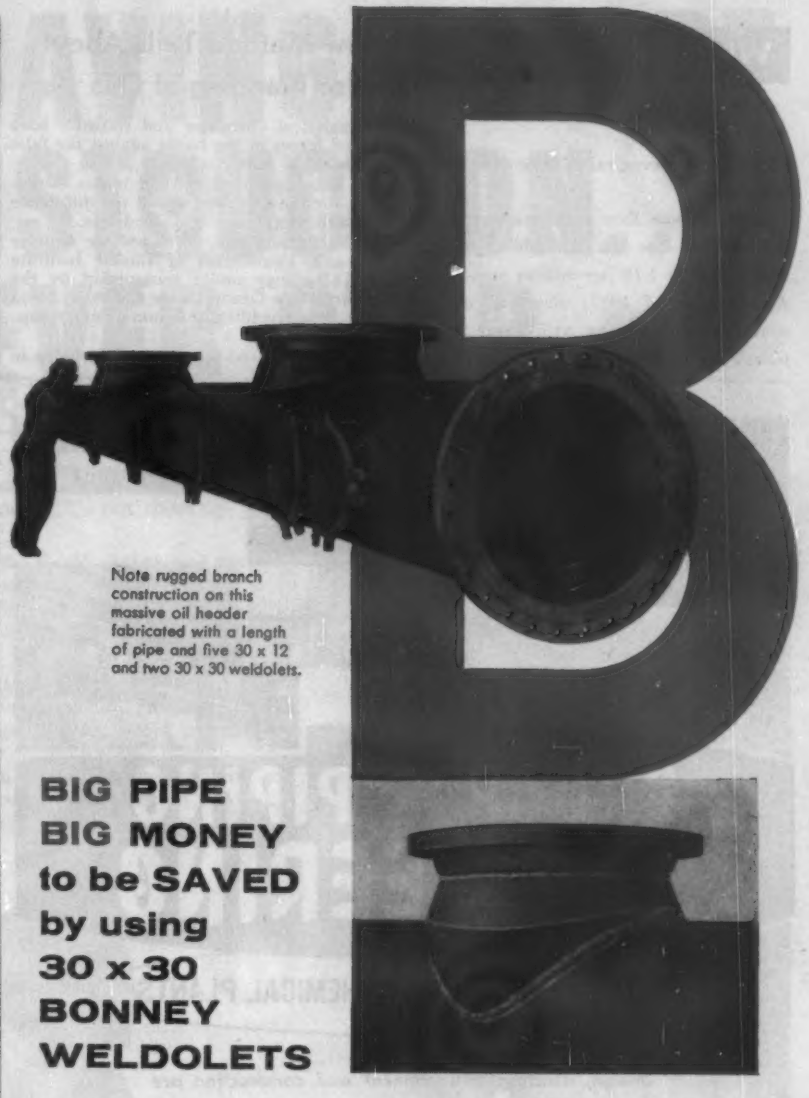
Wilshire owns and operates a 50,000 bpd plant at Norwalk, Calif., and carries on marketing activities in Los Angeles Basin, San Francisco, Oakland, Fresno, Stockton and Sacramento areas.

The move marks Pontiac's entry into the retail marketing field. Pontiac has refineries at Corpus Christi and Purvis, Miss.

Accidents Scarce at Esso

Accidents ran into a recession in 1957, at the nation's largest oil refinery.

At the big Esso Standard Oil Co. plant in Baton Rouge, the 1957 accident rate was 1.29 disabling injuries per million man-hours. Employees worked 7.5 million consecutive man-hours without a disabling injury. The record covered a span of 175 days. Accidents in other months of 1953



Note rugged branch construction on this massive oil header fabricated with a length of pipe and five 30 x 12 and two 30 x 30 weldolets.

BIG PIPE
BIG MONEY
to be SAVED
by using
30 x 30
BONNEY
WELDOLETS

Closer manifolding, ease and speed of field fabrication without header distortion, lower purchase and welding costs are just a few of the profit benefits of header fabrication with Bonney Weldolets. Today there is particular need for reducing costs. Bonney Forge can provide this opportunity for cutting costs in your company. Write, phone or wire for details.

BONNEY

WELDOLETS®
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CARBON STEEL
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ALLOY
for all services

BONNEY FORGE AND TOOL WORKS
DEPT. M ALLENTOWN, PENNSYLVANIA

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening. . .

and 1954, however, raised their rates above last year's.

Baton Rouge Esso employes established the 1939 all-time low in disabling injuries with a rate of 1.19 per million man-hours. At the close of 1957, they had worked nearly 4 million man-hours since the plant's last disabling injury.

New Method Tells About False Branding of Oils

Analytical chemistry and statistics have joined forces in the battle against the false branding of motor oils.

A new analytical method makes it possible for the first time to tell the difference between virgin and reclaimed oils.

The method was developed by Armour Research Foundation of Illinois Institute of Technology under sponsorship by the Pennsylvania Grade Crude Oil Association with both member and non-member support.

Up to now, no consistent differences in chemical properties of the two oils have been found to permit development of a procedure to identify them.

In a new approach to the problem, Foundation scientists have shot infrared rays through the oils and found statistical differences sufficient to provide identification of one from the other, according to Clark E. Thorp, manager of the chemistry and chemical engineering department. The infrared method detects the multiplicity of crude sources in the reclaimed oil, in contrast with the single or small number of crude sources of the virgin oil.

New Shell Air Analyzer

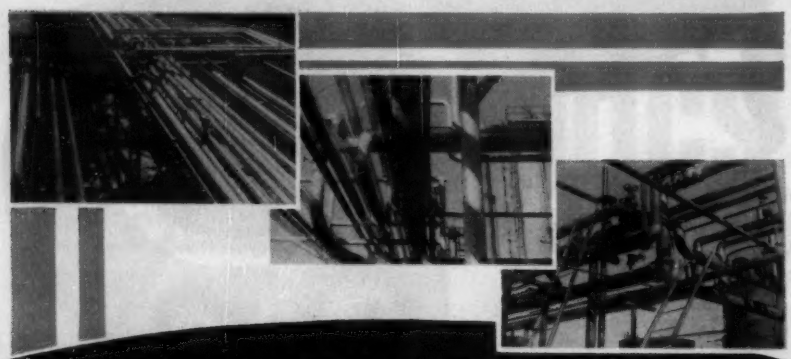
A new analtyical technique for air pollution studies has been offered free to interested research groups by Shell Development Co.

The new technique makes possible for the first time the rapid separation and identification of a wide range of hydrocarbons in quantities as low as 4 parts per 100 million parts of air. Applied to automotive exhausts, it provides rapid information on the type and quantity of hydrocarbons which emerge from the engine unburned or only partly burned.

Perfected at Shell's research center in Emeryville, Calif., the technique employs gas chromatography. Analyses are made by passing air samples through a long tube filled with finely ground solid material which physically separates various gaseous compounds from one another. They emerge separately from the column and are automatically recorded.

Philippine Plant Pact Set

Gulf Oil Co. has announced an agreement under which it would have a minority interest in a Philippines refining-marketing



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REFINERIES and PETROCHEMICAL PLANTS

Design, drafting, procurement and construction are among the complete services we provide to meet your piping needs.

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- ✓ Refrigerant Temperatures
- ✓ Alloys and Non-metallics

Our staff will be pleased to consult with you on your piping design needs.

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YOUR SAVINGS START AT CONSTRUCTION... AND NEVER STOP

with K&M Asbestos-Cement Structural Sheets!

You save right at the start. K&M Asbestos-Cement Structural Sheets are low in initial cost. Inexpensive to install. To put them up, you need only ordinary carpenter's tools.

Maintenance costs are practically zero. K&M Asbestos-Cement Structural Sheets won't burn, rot, or corrode. Never need protective painting. They're weather-resistant and vermin-proof. K&M Structural Sheets consist of asbestos fibers combined with portland cement.

K&M Asbestos-Cement Structural Sheets reduce building or remodeling costs indoors and outdoors. They're excellent for exterior siding or interior sheathing . . . for fireproof partitions, walls, panelings, ceilings, lockers, storage bins, elevator casing linings, fume hoods, warm air ducts and table tops. K&M makes three types of Asbestos-Cement Structural Sheets: Linabestos, Apac, and Sheetflextos. *Write today* for more information.

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COMPANY • AMBLER • PENNA.
Factories: Ambler, Pa. • St. Louis, Mo.
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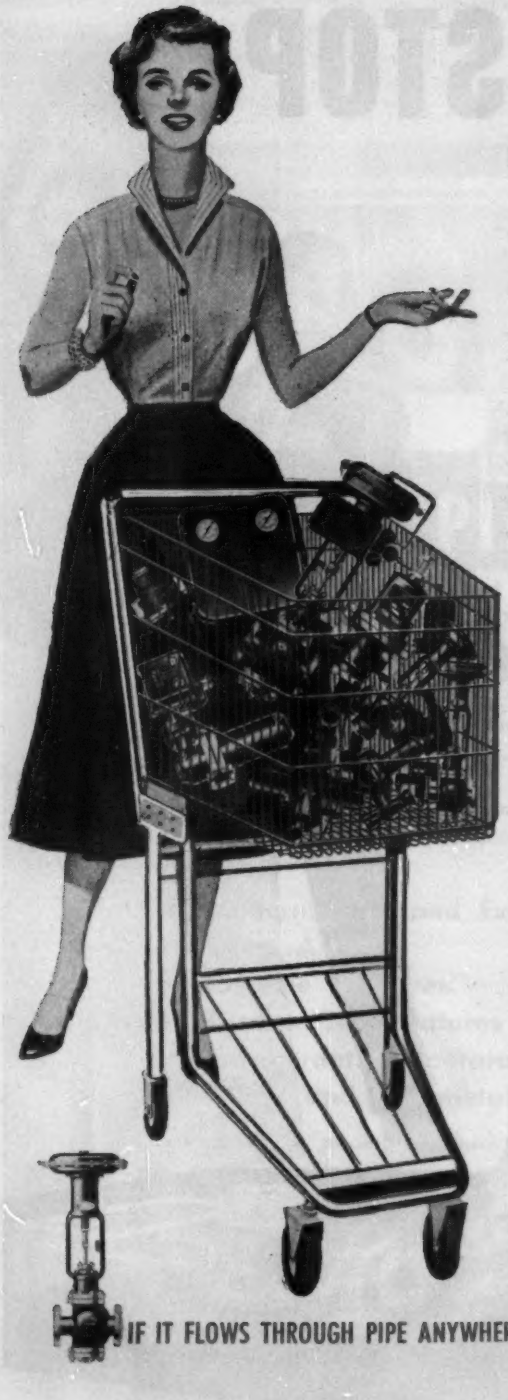
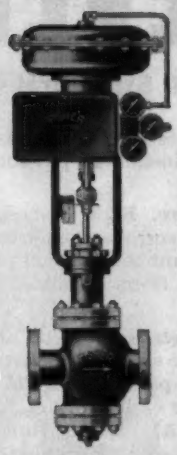
The FISHER

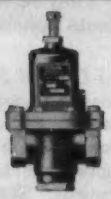
Stocked and Staffed to



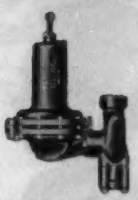


Type 657-A with 3500 Positioner

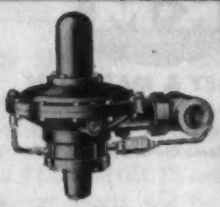
Type 4150 and 4160 Wizard II Pressure Controllers



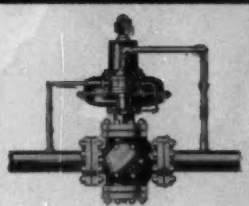
Type 95-H Pressure Reducing Valve



Type 630 "Big Joe" Field Regulator



Series 99-I Multi-Purpose Gas Regulators



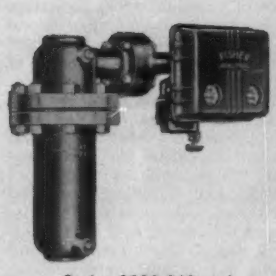
Series 298T Gas Regulators

Type 655-A Pressure Regulator

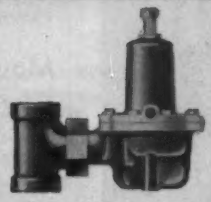
IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

"Supermarket"

give 36 hour Factory service!



Series 2500-249 and
2500-259B
Level-trols
Cage Sizes 14" and 32"



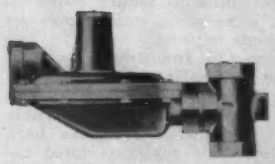
Series 620 and 621
Farm Tap Regulators

Series 67FR Combination Filter Regulator

Yes, now you can shop by phone, wire or TWX (Marshalltown 578 or 579) and expect shipment of the equipment illustrated at left in a matter of hours. Now that Fisher Control Valves and Regulators are as readily available as your supermarket groceries, you can meet your emergency needs quickly. Fisher carries a stock of the popular and standard size control valves, displacement type liquid level controllers, pressure regulators and gas regulators on the "supermarket" shelf at all times. The offices in red maintain a wide selection of Fisher equipment in their own inventory.

New items will be added from time to time as needed. Each Fisher representative receives a weekly list of all available types and sizes.

Now, for emergency needs contact either the Fisher representative or the Fisher home office. Your order will be en route within 36 hours (except Saturday and Sunday) after it is received in Marshalltown.



Series S100 and 730
Service Regulators

Type 92B Pilot
Operated Steam
Reducing Valve

AMARILLO
Vinson Supply Company
ATLANTA
J. M. Smither & Company
BALTIMORE
The Rhodes Controls Company
BIRMINGHAM
Joseph W. Eshelman & Company
BOSTON
Clarence B. Petty & Company
BUFFALO
W. J. Sommers Company
CALGARY-EDMONTON
Barber Engineering & Supply Company
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CHARLOTTE
Robert E. Mason & Company
CHICAGO
General Meters & Controls Company
CINCINNATI
H. T. Porter Company
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DALLAS
Vinson Supply Company
DENVER
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DETROIT
DuBois-Webb Company
HOUSTON-CORPUS CHRISTI
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Sullivan-Mears Company
LOS ANGELES
B. R. Jones & Company
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MONTREAL
Process & Steam Specialties, Inc.
NEW ORLEANS-LAFAYETTE
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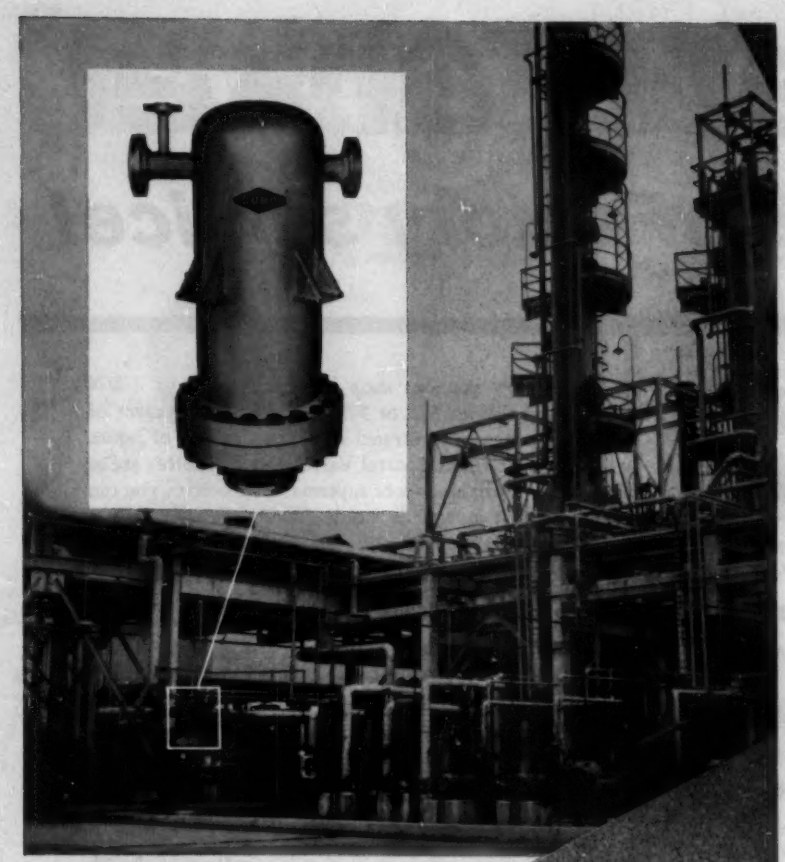
SEATTLE
Power & Controls, Inc.
TORONTO
George W. Boscroft & Company
TULSA
Vinson Supply Company
VANCOUVER
Northern Columbia Process Equipment Company
WICHITA-LIBERAL
Sullivan-Mears Company
WINNIPEG
Mechanical Valve & Engineering Spec.

Offices listed in red maintain field stock.

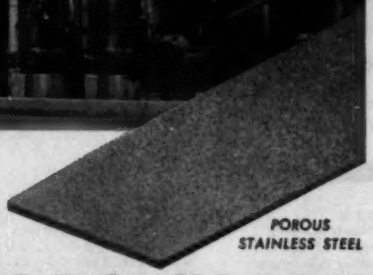
FISHER® Controls
SINCE 1880

FISHER GOVERNOR COMPANY
Marshalltown, Iowa/Woodstock, Ontario/London, England

For more data on advertised products, use Readers' Service Cards, last page.



Esso *selects*



CUNO

PORO-KLEAN
FILTER
for HYDROFINER

To remove catalyst fines from the Hydrofiner outlet stream – and thus prevent catalyst poisoning in the "reformer" – Esso selected a Cuno Poro-Klean Filter for its Baltimore, Maryland refinery. The fluid, heavy virgin naphtha of approximately 52.7 API, reaches the filter at 350°F. The Cuno Filter is a completely standard unit. Housing includes integral arrangements for in-place cleaning by backflushing and is built to meet A.S.M.E. Code requirements. For easy inspection, individual cartridges of sintered stainless steel are employed. The porous metal filter material manufactured by Cuno features a carefully controlled porosity that insures uniform fine filtration with complete removal of all catalyst particles.

Cuno Filters are now in service throughout the Petroleum Industry handling–

PRODUCT STREAMS · COMPRESSED AIR · PROCESS STREAMS
CHEMICALS · STEAM · SERVICE FLUIDS · ADDITIVES

WHATEVER YOUR FILTRATION PROBLEM . . . you can look to Cuno for the best possible unit to meet *your* specific needs. Remember ONLY CUNO offers you a truly complete line that includes all 5 types of filter media –

EDGE-TYPE • WIRE-WOUND • SCREEN • FIBER CARTRIDGE • POROUS METAL

CUNO **CUNO ENGINEERING CORPORATION**
3403 SOUTH VINE STREET, MERIDEN, CONN.
Designers and Manufacturers of Filters for Over Thirty Years

What's Happening. . .

company. The new company has not yet been named. A majority interest would be held by Philippine investors.

The agreement, subject to Philippine government approval, is with the Philippine Investment-Management Consultants, Inc.

A 10,000 bpd plant will be built on the island of Luzon, for which Gulf will supply crude, if the plan is approved. The plant is slated for completion in late 1960 or early 1961. Output would be marketed by Philippines.

Mounting Gasoline Stocks Cause Crude Cutbacks

In the face of gasoline stocks mounting higher and higher, many companies cut crude runs last month. Some of them were at plants which were already running at below capacity level.

Wilshire Oil Co. of California in order to help alleviate the problem of oversupply, temporarily reduced refinery throughput from 33,000 bpd to 25,000 bpd—a reduction of nearly 25 percent.

Standard Oil Co. (Indiana) and its affiliates cut their crude runs to refineries during January by 74,000 bpd or 11 percent, and will reduce their February and March runs by 40,000 bpd, or 6 percent, as compared with the same periods a year ago.

City Service operating companies cut back their total refinery runs of crude oil by 20,000 bpd, equivalent to eight percent of January runs.

The principal reduction will be at the Lake Charles, La. refinery, largest in the Cities Service system.

The refinery cutback will require the operating companies to reduce crude oil purchases in some areas, until supply-demand conditions improve.

Kerr-McGee Oil Industries, Inc., announced it is cutting its refinery runs by five percent, effective immediately. The company's refineries at Cushing, Wynnewood and Cleveland, Okla., have been operated below their aggregate rated capacity for some time.

Gulf Oil Co. has reduced runs in the Gulf Coast area by about eight percent. The company's 120,000-bpd crude unit at the Port Arthur plant will be down for the annual turnaround during the entire month of May.

The company has announced that present runs cutback and plans for overhaul of the crude unit at the Port Arthur plant will not cause any reduction in the work force at present.

Continental Oil Co. announced two cuts within one week's time with a 5,000 bpd reduction at its Lake Charles, La., refinery.

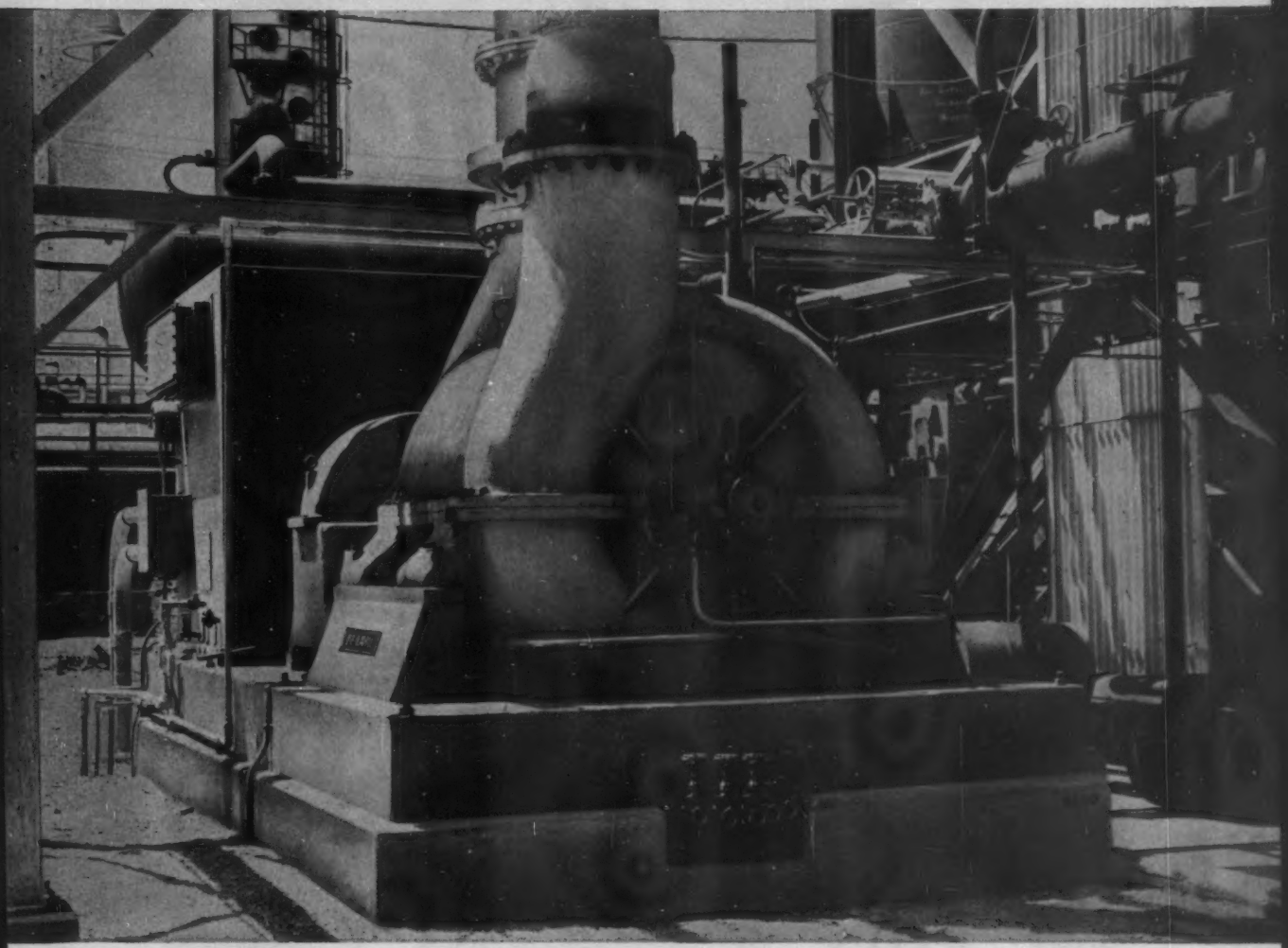
New Asphalt Members

Three new member companies have been welcomed into The Asphalt Institute. The additions are Douglas Oil Co., Los Angeles; Edgington Oil Refineries Inc., Long Beach, Calif.; and Warrior Asphalt Corp., Tuscaloosa, Ala. This brings the number of institute member companies to 59, including virtually all the major oil companies.

President J. E. Buchanan reported a slight dip in asphalt sales during 1957, due largely to spring storms which set back paving schedules, particularly in the Southwest.

For more data on advertised products, use Readers' Service Cards, last page.

Another DE LAVAL *combustion air compressor dependably serves refinery cat cracker*



On stream at the Coffeyville, Kansas plant of the Cooperative Refinery Association, this De Laval Centrifugal Compressor delivers 24,100 cfm of air. Inlet pressure is 14.0 psia, discharge pressure 38.9 psia. Compressor output is controlled with adjustable inlet guide vanes.

This De Laval main air compressor is driven by a 2500 hp, 1800 rpm motor. Shaft speed is increased to 4800 rpm through a De Laval double helical speed increasing gear.

Cooperative Refinery Association is only one of many refiners who have specified De Laval Compressors. Whether you need to handle light or heavy gases at high or low pressures in catalytic cracking, reforming, alkylation, coking or any similar service, it pays to look to De Laval. Rugged De Laval centrifugal compressors perform dependably in heavy-duty continuous operation. De Laval has more than 40 years of experience in solving gas compression problems.

DE LAVAL *Centrifugal Compressors*

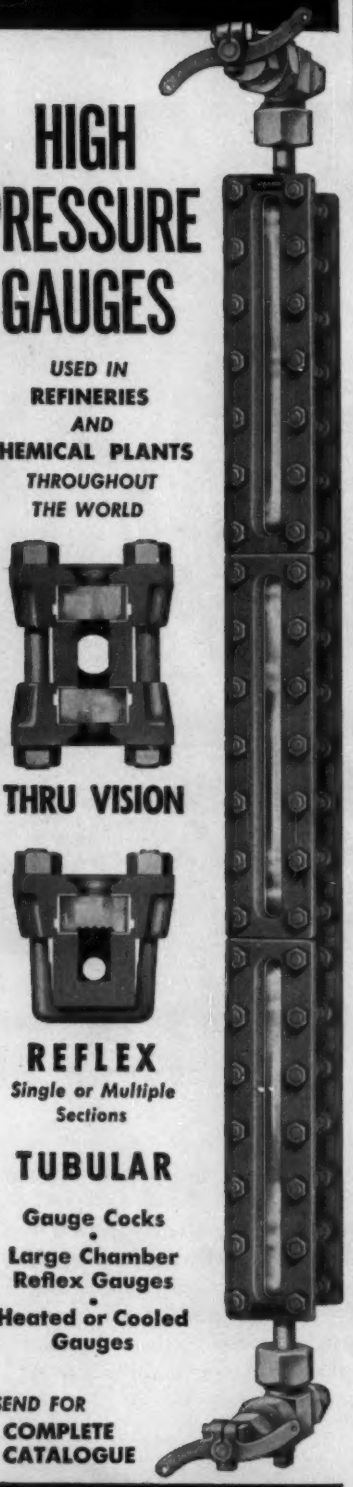
DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

DL393

Strahman

HIGH PRESSURE GAUGES

USED IN **REFINERIES** *AND* **CHEMICAL PLANTS** *THROUGHOUT THE WORLD*



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REFLEX
Single or Multiple Sections

TUBULAR

Gauge Cocks
•
Large Chamber Reflex Gauges
•
Heated or Cooled Gauges

SEND FOR **COMPLETE CATALOGUE**

STRAHMAN VALVES, Inc.
16 Hudson St., New York 13, U.S.A.

Changing Times

Union Carbide Corp. has decided to **put off, pending further study,** plans to construct a new office building and two laboratories in Eastview N. Y.

Soiel-Boreh, the organization of industrial enterprises of the Labor Federation of Israel, **plans full scale production of lubricants.** Project will require $11 million investment.

Frontier Refining Co., has a major interest in the newly formed Metal Alkyls Corp., which will manufacture high-energy fuels. The newly formed organization will, in conjunction with Frontier, proceed with plans for the manufacture of high-energy fuels in both test and commerical quantity.

Cuts in expenditures for military fuels are contained in Eisenhower's **1959 budget.** Fuel for the military services will cost **$730 million.**

Illinois Institute of Technology scientists have worked out **mathematical** relationships which may help in **designing future refining processes.** The new formulas were two years in the making by J. M. Dowling, R. Golf, and A. G. Meister. The equations simplify determinations of molecular vibrational frequencies. These frequencies lead to **thermodynamic data used to predict the practicality of proposed chemical processes.**

The Borden Co. promoted its **chemical division to company status.** New name: **The Borden Chemical Co.,** division of The Borden Co.

du Pont board of directors' safety award has been won for the 5th time by the 400 man construction force at the company's Chambers works, Deepwater Point, N. J. **The unit has gone nearly eight years without a time losing accident—25 years without a fatality,** and set world safety mark for the industry June 5, 1956.

Ohio-Standard lost another round in its fight to use the Sohio trademark in Indiana-Standard's territory. U. S. Court of Appeals in Denver upheld an earlier band.

By stockholder action, the **name of Venezuelan Petroleum Company has been changed to Sinclair Venezuelan Oil Company.** Under new name, company will continue its oil exploration, production and refining operations in Venezuela **as the subsidiary of Sinclair Oil Corp.,** which owns 96.24 percent of the company's stock.

Send for your **FREE** copy of the **New Petroleum Books Catalog** containing descriptions of many books pertaining to the Petroleum Industry. Send your request to **Book Department, Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.**

MEETINGS CALENDAR

1958	
MAR.	
17–21	Fourth Nuclear Engineering and Science Conference, Chicago International Amphitheatre.
17–21	National Association of Corrosion Engineers, National Meeting, Civic Auditorium, San Francisco.
19–20	ASME Engineering Management Conference, Somerset Hotel, Boston.
24–26	Western Petroleum Refiners Association, 46th Annual Meeting, Hilton Hotel, San Antonio, Texas.
26–28	American Power Conference, 20th Annual Meeting, Hotel Sherman, Chicago.
APRIL	
1– 3	ASME Instruments and Regulators Conference, University of Delaware, Newark, Del.
13–18	American Chemical Society, 133rd National Meeting, San Francisco, Site Unreported.
1–15	ASME Maintenance & Plant Engineering Conference, Penn-Sheraton Hotel, Pittsburgh.
14–17	ASME Design Engineering Conference, International Amphitheater, Chicago.
14–18	American Welding Society, Annual Technical Meeting and Show, Hotel Statler, St. Louis, Mo.
15–17	Southwestern Gas Measurement Short Course, University of Oklahoma.
17–18	Society of Petroleum Engineers of AIME, La.-Ark., East Texas and Miss. Petroleum Sections, Gas Technology Symposium, Site Unreported.
20–23	American Institute of Chemical Engineers, Montreal, Canada.
22–24	American Society of Lubrication Engineers Annual Meeting, Cleveland, Site Unreported.
24–25	ASME Management—SAM Conference, Statler Hotel, New York.
27–29	Independent Petroleum Association of America, Mid-year Meeting, Hotel Sherman, Chicago.
MAY	
5– 7	Purdue Industrial Waste Conference, Purdue University Memorial Union Building, Lafayette, Ind.
5– 9	API Safety and Fire Protection Committee, 11th Midyear Meeting, Cosmopolitan Hotel, Denver.
11–15	ASME Oil & Gas Power Conference & Exhibit, Bellevue-Stratford Hotel, Philadelphia.
12–14	Analysis Instrumentation Division of the Instrument Society of America, Annual Symposium, Shamrock Hilton Hotel, Houston.
12–15	API Division of Refining, Midyear Meeting, Statler Hotel, Los Angeles.
25–29	API Pollution Control Association, Annual Meeting, Sheraton Hotel, Philadelphia.
JUNE	
4– 6	American Petroleum Institute, Oil Information Committee Meeting, Sheraton Hotel, Chicago.
18–28	Chemical and Petroleum Engineering Exhibition, Olympia, England.
22–27	American Institute of Chemical Engineers, 50th Anniversary Meeting, Bellevue-Stratford Hotel, Philadelphia.

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Write for free booklet on preparation of articles for PETROLEUM REFINER, the technical press generally, as well as papers for technical meetings.

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REGENERATES IN SITU!

Higher octane levels and longer catalyst life... with existing equipment ...merely by replacing with Sinclair-Baker RD 150 Platinum Catalyst

If you have the problem of increasing octane rating and production in your existing equipment, investigate the unique performance of Sinclair-Baker RD 150 Platinum Reforming Catalyst. Its efficiency in producing *important yield increases at high octane levels* is a matter of record. The long period of RD 150 operation is unmatched by any other catalyst... further, *it is regenerative in situ!* Cost is sharply reduced to lowest level.

A representative will be glad to give you detailed information, upon request. All data of confidential nature are of course treated accordingly.

ENGELHARD INDUSTRIES, INC.

CHEMICAL DIVISION

113 ASTOR STREET • NEWARK, N. J.

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . *Among Men* in the Industry

Frank W. Pierson has been named manager of Standard Oil Co. of Calif.'s department on organization. Piersol succeeds **Lewis L. Purkey** who retired February 1.

Piersol joined Standard's Marketing department in 1925. In 1936 he was assigned to the comptroller's staff in San Francisco. In 1940 he transferred to the department on organization where he served as head of the wage and salary division and later returned as manager.

He helped develop Standard's executive plan of organization, placed in effect in 1954. In his new post he will direct organization and compensation planning for most of Standard's operations throughout the Western hemisphere.

Carl B. Whyte, president of Procon, Inc., Des Plaines, Ill., has been elected president of National Constructors Association. Also elected were **W. R. Wood,** president, Girdler Corp., Louisville, vice president, and **R. E. Atkinson,** assistant labor relations manager, Koppers Co., Inc., chairman of the labor committee.

The National Constructors Association is an organization of engineering and building firms specializing in design and construction of chemical plants, petroleum refineries, steel mills and power plants.

Retiring president is **C. D. Haxby,** vice president, Rust Engineering Co., Pittsburgh.

Henry Flynn, general superintendent of The Texas Co.'s Port Arthur, Texas, refinery, has been named manager. He succeeds **F. L. Wallace,** who is retiring.

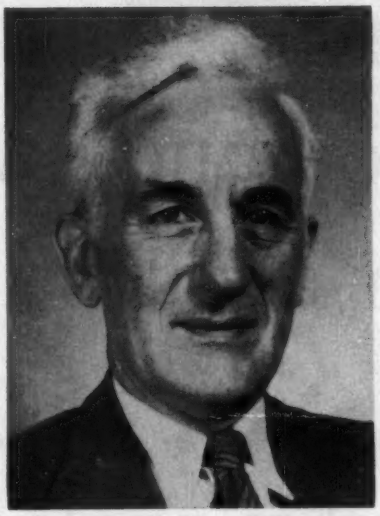
Flynn

Flynn has been general superintendent since Jan. 1, 1956. He graduated with a B. S. degree in electrical engineering from the Massachusetts Institute of Technology in 1923.

He started work with Texaco in 1927 in the Refining department's Terminal division in New York and was transferred the next year to the Port Arthur works. In 1943 he was appointed assistant to the superintendent of manufacturing and two years later became assistant superintendent. In 1953 he was named superintendent of manufacturing, the position he held until his appointment as general superintendent in 1956.

E. W. McNealy, Flynn's replacement as general superintendent, graduated in 1932 with a B. S. degree from Rice Institute. He joined Texaco the same year. He has been assistant superintendent at three Texaco refineries, and superintendent at two others.

Sun's "Parallel Ladders" Plan Promotes Kurtz and Barcus



Stewart S. Kurtz, Jr.

W. Herman Barcus

Creation of parallel ladders of progression—administrative and scientific—in Sun Oil Co.'s Research and Development department has been announced by Dr. Charles L. Thomas, director.

The honor of the first formal appointment as research scientist went to Stewart S. Kurtz, Jr., formerly head of the Analytical division of Research and Development at Marcus Hook.

In a re-alignment of research service work, W. Herman Barcus becomes manager of a new Research Service division and Robert W. Donahue manager of the Product Development division which Barcus formerly headed.

The research work of the former Analytical division will be brought together in the Basic Research division and freed of service responsibilities.

The new post of research scientist makes it possible for Kurtz to furnish scientific leadership in the department and to pursue, without administrative distractions, his research specialties.

Kurtz has both undergraduate and graduate degrees from Harvard University. He joined Sun in 1935 as a research chemist and became manager of Sun's research laboratory at Norwood, Pa., in 1942. He was named analytical division manager in May, 1953. Active in technical work for the American Society for Testing Materials, he also is past chairman of the American Chemical Society's petroleum division. He received the Louis Edward Levy Gold Medal of the Franklin Institute for his publications on refractive index.

Barcus worked as a chemist and chemical engineer for 20 years with Sun before being named manager of the Development Laboratory in 1948. He became manager of the Product Development division in 1953. A graduate of Swarthmore College with a B.S. degree in chemistry, he has been active in several technical societies.

In his new post, Barcus will integrate the services of the former Administrative division and other research service activities.

Donahue, who has been with Sun since 1941, served in various engineering posts in the Automotive Laboratory before being named a section chief in 1953. He is a graduate in chemical engineering from Purdue University, and is active in the Society of Automotive Engineers.

W. B. Reynolds has been named director of research for Phillips Petroleum Co.

Reynolds, who was assistant director of research, succeeds **J. A. Reid,** who has been appointed executive vice president and general manager of Astrodyne, Inc., new solid fuel rocket engine company jointly owned by Phillips and American Aviation, Inc. **D. E. Carr** will be the assistant director of research for Phillips, and

HE CAN "MEASURE" MORE PROFIT FOR YOU. This Dowell service engineer can measure the amount of scale he removes from a line, using the Dowell method of chemical cleaning. *This removed scale and sludge can also be measured in increased profit dollars for your company.*

Example: Scale build-up in the main water supply line of a major Midwestern plant had reduced the "C" factor from 105 to 72. This situation became apparent just at the start of the peak season for the company. Management had a choice between laying an auxiliary line or trying to clean their present one. They decided to clean the line—but not the old-fashioned mechanical way. Time would not permit. Dowell was called in to do the job—chemically.

Dowell Service was fast—the job was done in three days. Dowell Service was effective—the "C" factor was increased to 92. Dowell Service was profitable for the customer—$71,000 was saved and the company's annual profit was protected.

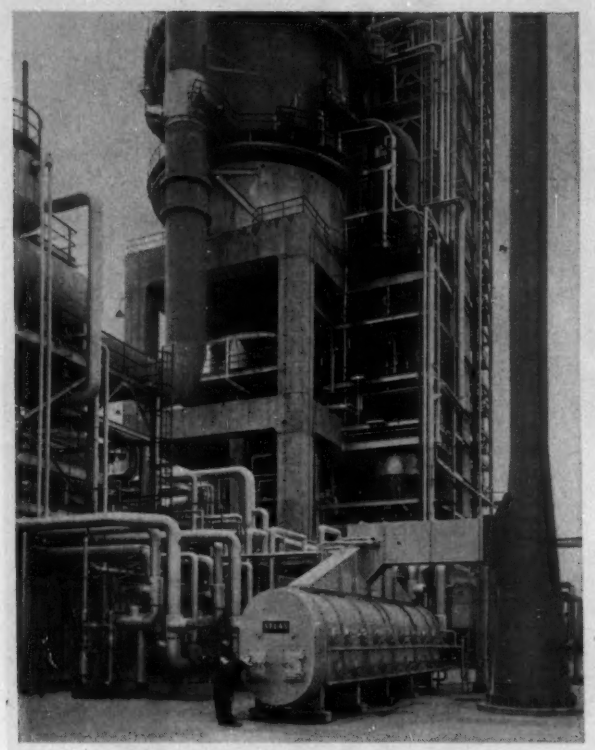
With Dowell Service you receive the benefits of more than fifteen years experience in chemical cleaning—plus a full line of equipment, chemicals, and trained personnel. You pay one charge, get an efficient job, handled by experienced people.

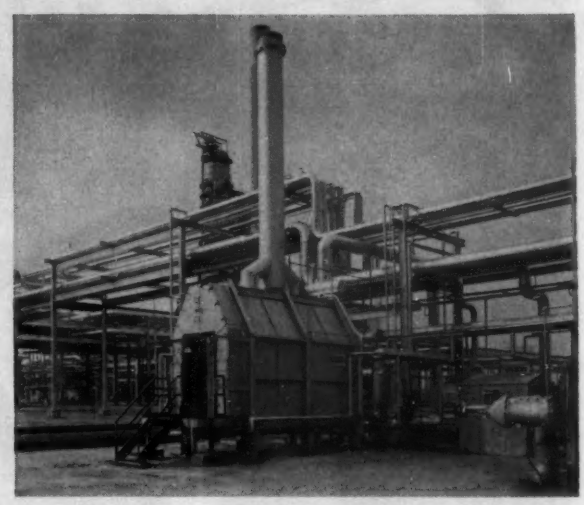
Your maintenance and operating engineers probably know about Dowell Service. Ask them for the facts. Decide for yourself about the additional profit possibilities to your company with Dowell Service working for you. DOWELL INCORPORATED—A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa, Oklahoma, with 165 offices and stations to serve you.

Chemical cleaning service for industry DOWELL

our research is your reward

GRADIATION® and ECONOTHERM* . . . Selas Heaters designed and built to meet your processing needs





The Gradiation barrel-type heater (left) superheats steam in two precisely-controlled stages of Tidewater's continuous coking process. The Econotherm heater (above), designed and built to serve low cost requirements where precision heating is not a consideration, maintains asphalt in fluid form for easier handling.

. . . perform critical and non-critical operations at Tidewater Oil Company's ultra-modern Delaware Refinery

Selas is proud to have a part in the development of Tidewater Oil Company's Delaware plant, the largest refinery ever built at one time. Here, where initial capacity is 130,000 b/d:

- Gradiation heating meets critical processing requirements
- Econotherm heating serves non-critical demands

Each heater is designed and built to perform its specific function.

When the petroleum, petrochemical and chemical industries require preciseness in heating, ability to handle a variety of feed stocks, instant response to controller demand, Zone Control . . . they specify Gradiation. When heating is to be performed below the decomposition point of the material, when low first cost is the important factor . . . they choose Econotherm. Both are Selas heaters; both bring to each process Selas knowledge, skill, experience and service.

Write Dept. 73 for bulletin "Gradiation Heating for Petroleum and Chemical Processing."

* Trade Name

Gradiation is a registered trade name of Selas Corporation of America.

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CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers
DEVELOPMENT • DESIGN • CONSTRUCTION

Men in the Industry . . .

F. E. Frey and T. W. Legatski will be associate directors of research with staff responsibilities.

Reynolds received his B.A. degree from Cornell College in 1934. Two years later he earned his PhD. degree in chemistry from the University of Chicago. He joined Phillips in 1946 as supervisor of synthetic rubber research, and directed development work on cold rubber. He was promoted to assistant director of research in 1950.

Carr, a graduate of the University of California, joined Phillips in 1947 as an associated director of research and later became supervisor of the lubricants research section. In 1950, he became an assistant director of research, responsible for combustion and lubrication work, and is the assistant director for all research activities.

Frey has been an assistant director of research since 1944. He has worked with processes for aviation gasoline, motor fuels and synthetic rubber. Frey received his M.S. degree at Ohio State University. Wooster College also has granted him an honorary D.S. degree.

Legatski joined Phillips after receiving his engineering degree from the University of Michigan in 1925 and became an assistant director of research in 1929.

Alfred B. Vought has retired as refining coordinator for Standard-Vacuum Oil Co. at its White Plains, N. Y., headquarters and has been succeeded by **William A. Williams.**

Williams

Vought had been refining coordinator since August, 1954. His 32 years of oil industry experience included nearly eleven years with Stanvac in Indonesia.

Williams joined Stanvac in 1952, after 18 years experience in Canada, and served three years as chairman and managing director of its refining subsidiary in India during construction and initial operations of the company's Bombay refinery.

He entered the industry in 1934 as a laboratory technician at Imperial Oil Ltd's refinery in his hometown of Sarnia, Ontario, advancing to assistant superintendent of process operations. Between 1950-52, he was superintendent of Imperial's Montreal refinery. He is a 1934 engineering graduate of the University of Michigan.

Clyde T. Foster, chairman of the board of directors of The Standard Oil Company (Ohio), announced that the board has voted to increase the number of directors of the company from 9 to 12. Stockholders of the company at their annual meeting will be asked to elect directors to fill these additional places on the board.

Foster stated that management intends to nominate the following men to fill the three additional places: **T. Keith Glennan,** president of Case Institute of Technology, Cleveland; **Richard C. Sauer,** vice president, supply and distribution of The Standard Oil Co. (Ohio), Cleveland; and **Sidney A. Swensrud,** former chairman of

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QUALITY CONTROLLED VOLUME PRODUCTION
. . . YOUR ASSURANCE OF LASTING ECONOMY
Model 1200 Illustrated
MODELS: 1200, 660, 360 & 100-B
ANY SIZE TAPS UP TO 36"
EXCLUSIVE FEATURES:
● HARD CHROMED BORING BAR & SELF ADJUSTING PACKING
● WIDER RANGE OF TAPS WITH IMPROVED POWER SYSTEMS
● HEAVY DUTY BEARINGS AND DRY FILM LUBRICATION
ALL MODELS RATED AT:
1,440 PSI @ 100° F or
700° F @ 700 PSI
EACH MACHINE TESTED TO 2,175 PSI
Write for RENTAL-PURCHASE information & bulletins
36" Coupon
PIPELINES REFINERIES CHEMICAL PLANTS STEEL MILLS
T.D. Williamson, Inc.
P. O. BOX 4038 TULSA 9, OKLAHOMA
REPRESENTATIVES: HOUSTON • AMARILLO • PITTSBURGH • PLAINFIELD, N.J. • JOLIET, ILL. • JACKSON, MICH. • LOS ANGELES • SAN FRANCISCO BARTLESVILLE, OKLAHOMA • SEATTLE • SALT LAKE CITY • EDMONTON TORONTO • WINNIPEG • VANCOUVER • BUENOS AIRES • CABIMAS, ZULIA, VENEZUELA • DURBAN, NATAL, S. AFRICA • PARIS, FRANCE • SIDNEY, AUST.

THE ALL NEW SUB-X INERT GAS GENERATOR

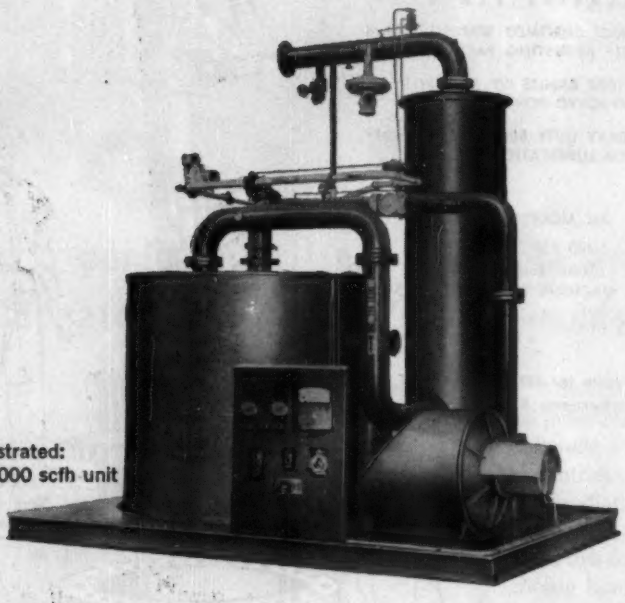
utilizes unique principles of design to provide refineries, chemical processors, metallurgical plants and other industrial users with a source of inert or purge gases that is compact in size . . . highly efficient . . . extremely economical to operate.

SUBMERGED EXHAUST OF COMBUSTION PRODUCTS

makes feasible the use of low-cost river or contaminated water as coolant. The tank of water through which the gases pass provides an unusual degree of safety to prevent flash-back between the burner and the process.

REFRACTORY IS ELIMINATED

and maintenance costs reduced through the use of the high heat release THERMAL burner which can be fired with either gas or distillate oil. Units are supplied as complete packages and include all control and safety equipment. Standard models will produce up to 60,000 SCFH of inert gas; larger capacity units can be designed to meet your specifications.



Illustrated:
50,000 scfh unit

FOR DETAILED INFORMATION
WRITE FOR BULLETIN #114

THERMAL

Thermal Research & Engineering Corp.

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REPRESENTATIVES IN PRINCIPAL CITIES

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Air Heaters
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Combustion & Heat Transfer Equipment

Men in the Industry . . .

the board of Gulf Oil Corp. and earlier the executive vice president of The Standard Oil Co. (Ohio).

Dr. Glennan has been president of Case Institute of Technology, Cleveland, since September 1, 1947, and served with the Atomic Energy Commission, Washington, D. C.

Sauer joined Sohio in 1922. Since 1930, he has been active in the management of the Supply and Distribution department, became manager in 1938 and was elected a vice president of the company in 1947.

Swensrud joined Sohio in 1928 as assistant to the president; became a vice president in 1939; a director in 1940 and executive vice president in 1946.

He left the company in 1947 to become executive vice president of Gulf Oil Corp. in Pittsburgh, becoming president in 1948 and chairman of the board in 1953. He resigned this position with Gulf in 1957.

Dr. Helen Sellei Beretvas has been appointed senior research scientist in the lubricants division of the Research department, Standard Oil Co. (Indiana).

Dr. Beretvas, who received her Ph.D. degree from the University of Budapest, joined Standard in 1947. Her research work has centered on lubricants used at extreme pressures. Corrosion, the role of sulfur compounds, and the synthesis of additives for these lubricants are some of the problems in which she has specialized. She was elected a fellow of the American Association for the Advancement of Science in 1956.

The company also announced that **L. James Schmauch** has been named senior research scientist in the analytical research division of Standard's research department.

Schmauch graduated from Pennsylvania State College and joined the company in 1936. His researches have been in the analysis of the complex mixtures found in petroleum and petroleum products. Most recently he has worked in the field of gas chromatography.

Henry B. Wilson, Jr., has been elected president of Esso Standard Espanola S. A., marketing affiliate of Standard Oil Co. (New Jersey), in Spain.

Wilson

Formerly vice president of Esso Standard of Brazil, Wilson succeeds **Guy S. Warner,** who is retiring.

Wilson received a degree in petroleum engineering from the University of Oklahoma in 1928. He joined Jersey Standard the following year as a student engineer with the Humble Oil & Refining Co. From 1936 until 1941, he was employe relations manager for Jersey affiliates in Argentina and Venezuela.

Returning to the U. S. in 1941, Wilson served with Jersey Standard's employe relations department until 1943 when he entered the military. He was discharged in 1945 and became assistant manager of the employe relations department in 1948.

In September, 1951, he was elected a di-

"B&W Welded Stainless Steel Tubing resists corrosion because it is fully annealed and precision made

As a design engineer working with heat exchanger and condenser applications, I know the importance of selecting tubing that's fully annealed. That's why I choose B&W Welded Stainless Steel Tubing. It gives me resistance to corrosion, ease of fabrication and close tolerances that I want."

B&W's production practice of fully annealing all welded stainless steel heat exchanger and condenser tubing and performing a minimum amount of cold work after heat treatment achieves the ideal condition of maximum general corrosion resistance and close size tolerances. This provides ease of fabrication and threading of tubing through baffles and tube sheets and minimizes the possibility of failures in service due to combinations of stress and corrosion.

For further information, call Mr. Tubes, your nearest B&W representative—he can help you solve any tubing problem—or write for Bulletin TB-415. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

B&W TUBULAR PRODUCTS DIVISION

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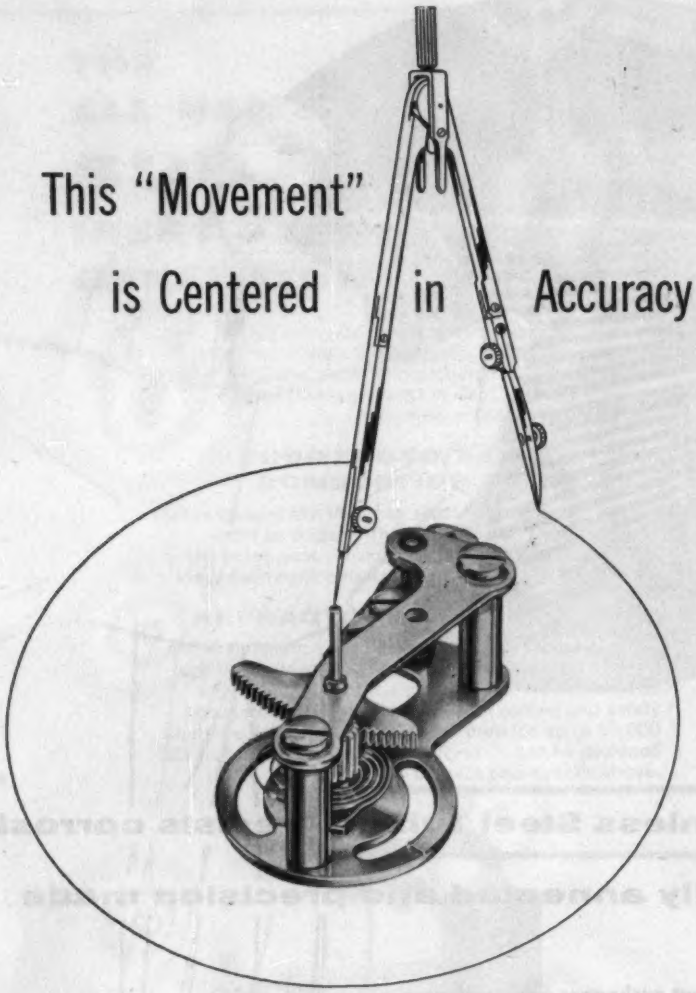
Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

This "Movement" is Centered in Accuracy



The rotary movement in Ashcroft Duragauges has a geared center shaft on which the pointer is mounted. When pressure flexes the Bourdon tube, the pointer is always positively positioned. You can rely on the Duragauge for precise accuracy in measuring pressure no matter how severe the conditions of service.

Correct calibration is guaranteed: the one-piece link between movement and Bourdon tube prevents slippage or parting under tension. Recalibration is easy from front or rear. Universal adjustability permits uniformly graduated dials.

You can order Ashcroft Duragauges with all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. A complete choice of Bourdon tube materials, pressure ranges, dial sizes and case designs and materials is available. Your industrial supply distributor will gladly help you select the best combination for your requirements. So, be certain of highest sustained accuracy, durability and economy – specify Ashcroft Duragauges.

Ashcroft Duragauge in Alumalife® case—a lifetime case made of special aluminum alloy.

MAXWELL MANNING M&M & MOORE, INC. TRADE MARK

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A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut

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G1-58

Men in the Industry . . .

rector of International Petroleum Co., Ltd., where he remained until his election as vice president and director of Esso Standard of Brazil in 1954.

E. W. Kilgren, chief plant engineer for the production department, Pan American Petroleum Corp., Tulsa, has been appointed vice chairman of the Technical committee of the Natural Gasoline Association of America.

Kilgren

Kilgren will aid the present chairman of the committee, **Charles E. Webber,** technical advisor to the vice president of Sun Oil Company, Philadelphia.

Kilgren received his B.S. degree in chemical engineering from Michigan State University in 1940, and a M.S. degree from the University of Michigan in 1941. He joined Stanolind at that time, serving in the research department, Tulsa. In 1943, he joined the Field Research department of Magnolia Petroleum Co., Dallas, becoming supervisor of the process design and economics section.

He returned to Tulsa in 1946 to join the Development section of Stanolind's Manufacturing department. In 1950, he was made chief development engineer of the Manufacturing department, and was promoted to his present position in 1953.

Everette E. Kerns has been appointed to the newly created post of engineering consultant on safety administration in the home office of the manufacturing department of The Standard Oil Co. (Ohio).

Kerns

Kerns, who has been with Sohio since 1934, was promoted from section supervisor for the general engineering division's engineering service section, where **John J. Graham** succeeds him.

Kerns earned a degree in mechanical engineering at Carnegie Institute of Technology.

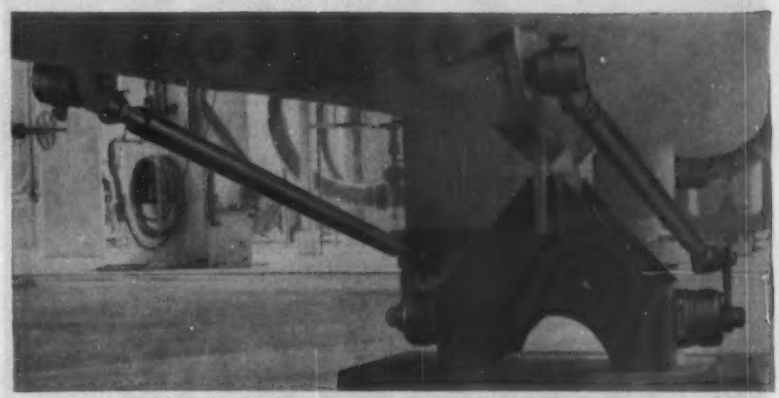
Graham is a graduate of Case Institute of Technology, with B. S. and M. S. degrees in mechanical engineering. He has been with Sohio since 1946.

J. S. Worden, vice president in charge of The Texas Co.'s Refining department, today announced that Henry Flynn, general superintendent of the company's largest refinery, at Port Arthur has been named manager. He succeeds F. L. Wallace, who is retiring.

E. W. McNealy, assistant general superintendent since June, 1957, will succeed

stop vibration damage

HOUDAILLE rotary shock absorbers



● Houdaille units installed on a regenerative riser line at a California cracking plant.

IN REFINERY AND PIPELINE OPERATIONS, Houdaille Rotary Shock Absorbers offer the *most practical solution* to pipeline vibration caused by the surge of oil under high pressure and temperature. If not controlled, this vibration and "pipe hammer" soon causes pipe fatigue, with cracking and leaking at joints and welds.

HOUDAILLE ROTARY SHOCK ABSORBERS are recommended and used by leading refinery designers and engineers throughout the world.

Exclusive rotary design ● Easily installed ● Readily serviceable ● Sealed against dirt, water, corrosion ● Long trouble-free life

Write for **FREE TECHNICAL BULLETIN** on Houdaille Rotary Shock Absorbers.

HOUDAILLE FIELD ENGINEERS are available for consultation. Or send details of your problem direct to . . .

Houdaille Industries inc.

BUFFALO HYDRAULICS DIV. • 537 E. Delavan Ave., Buffalo 11, N. Y.

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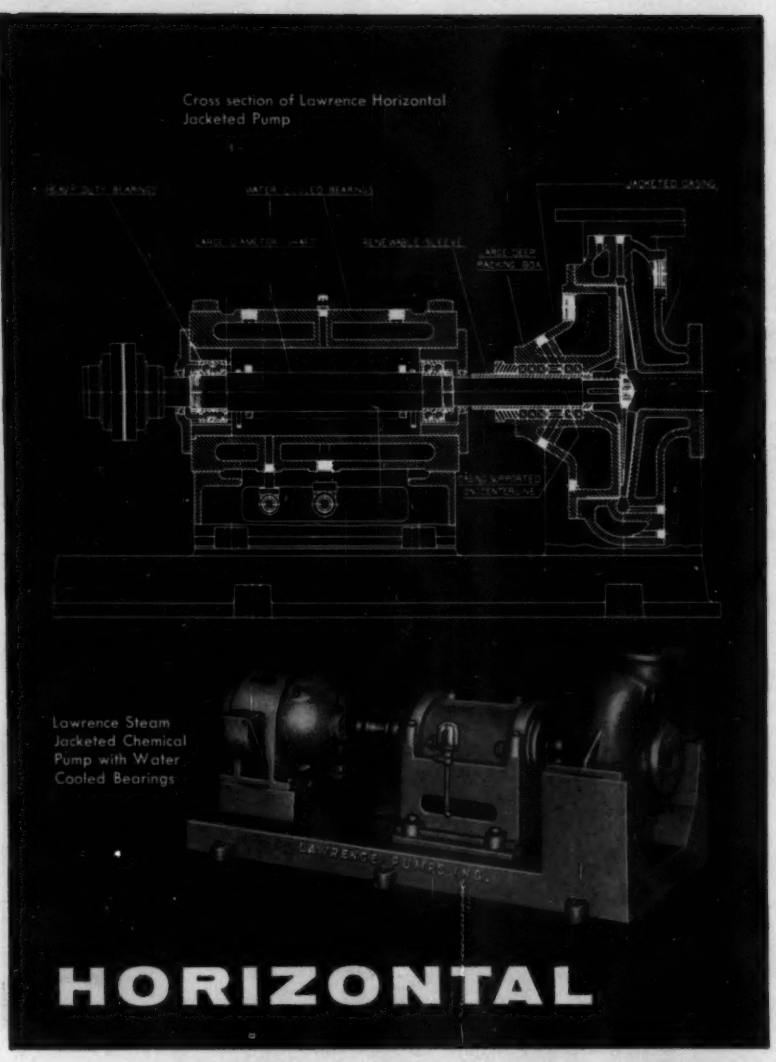

Cross section of Lawrence Horizontal Jacketed Pump
Lawrence Steam Jacketed Chemical Pump with Water Cooled Bearings
HORIZONTAL

jacketed PUMPS

Lawrence jacketed pumps are designed to pump liquids such as sulphur, phthalic anhydride, resins, waxes, etc., which tend to solidify or become viscous at low temperatures. The heating medium can be steam, dowtherm, etc., and all heating spaces are vented and self-draining.

The bearings are heavy-duty, water-cooled. Misalignment and distortion, which might be caused by thermal expansion, are eliminated by supporting the casing along the center line of the shaft.

If you have to pump liquids which must be held above a specified temperature to retain their fluidity, write us the pertinent details. No obligation.

Write for Bulletin 203-7.

LAWRENCE PUMPS INC.
371 Market Street, Lawrence, Mass.

Men in the Industry . . .

Flynn as general superintendent.

Flynn has been general superintendent since Jan. 1, 1956. He graduated with a B.S. degree in electrical engineering from the Massachusetts Institute of Technology in 1923. He started work with Texaco in 1927 in the Refining department's Terminal division in New York and was transferred the next year to the Port Arthur Works. In 1943 he was appointed assistant to the superintendent of manufacturing and two years later became assistant superintendent. In 1953 he was named superintendent of manufacturing, the position he held until his appointment as General Superintendent in 1956.

McNealy graduated in 1932 with a B.S. degree from Rice Institute. He joined Texaco the same year. He has been assistant superintendent at three Texaco refineries, and superintendent at both the Eagle Point, N. J., and Lockport, Ill., works.

William H. Rader has been made U. S. Industrial Chemical Co.'s assistant production manager for Petrothene Polyethylene resins. U. S. I. is a division of National Distillers and Chemical Corp.

Rader

Rader studied at the Illinois Institute of Technology and received a B. S. degree in chemical engineering in 1948. He was employed in 1948 by the chemical products division of Esso Standard Oil Co. until 1953, when he joined National Petro-Chemicals Corp. as Senior Technologist. Rader has performed customer service work, and as senior development engineer had charge of polyethylene development operations at the company's Tuscola plant.

William K. Jackson, former director of the chemical division, Cosden Petroleum Co., has been named vice president of research and development, The Vickers Petroleum Co., Inc., Wichita. In his new assignment, Jackson will also act as assistant to the president and work with **Arthur B. Mullaly** and **Dewey Mark** in the organization of Vickers Chemical division, recently formed by The Vickers Petroleum Co., Inc.

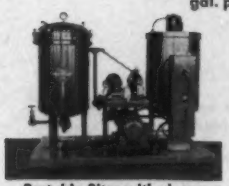
Jackson

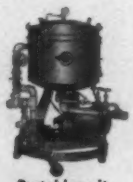
Mullaly is a former president of Advance Solvents and Chemicals Co., New York. He has been named vice president of market and market development for Vickers Chemicals division.

Dewey Mark, former chemical and sales manager, Cosden Petroleum Co., has joined the Vickers Chemicals Division as its general sales manager.

Jackson received a degree from Rice Institute, while Mullaly graduated from the Stevens Institute of Technology and

For more data on advertised products, use Readers' Service Cards, last page.


Portable filter with slurry tank and feeder.


Portable unit, explosion proof.

Portable unit corrosion proofed, rubber lined with plastic plates.

Portable filter for polishing operations.

Low cost Vacuum Filter.

The most complete line of filtration equipment- engineered to meet the requirements of hundreds of products

By concentrating on filtration engineering and manufacturing exclusively for over 30 years, Sparkler is able to offer a solution to practically all filtration problems without expensive experimentation.

Standard filter models available for:

Chemicals	Electroplating	Varnish
Pharmaceuticals	Petro Chemicals	and Lacquers
Beer,	Petroleum Derivatives	Hydraulic Oil
Whiskey, Wines	Food Products	Steam Condensate

and many other products in addition to large volume water filtration for municipal and plant use. Personal service on all filter installations.

SPARKLER
MANUFACTURING CO.
MUNDELEIN, ILL.

SPARKLER INTERNATIONAL LTD. with manufacturing plants at

Ontario, Canada	Australia	Amsterdam, Holland	Milano, Italy
1115 Castelfield Ave.	Homebush N.S.W.	Leliegracht 9	c/o Serapis s.r.l.
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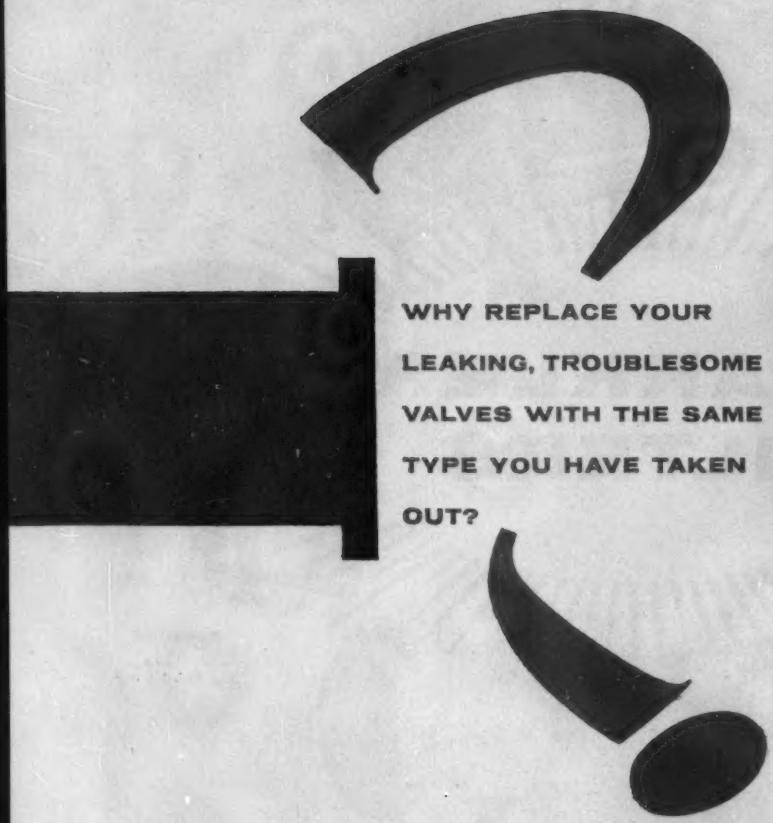
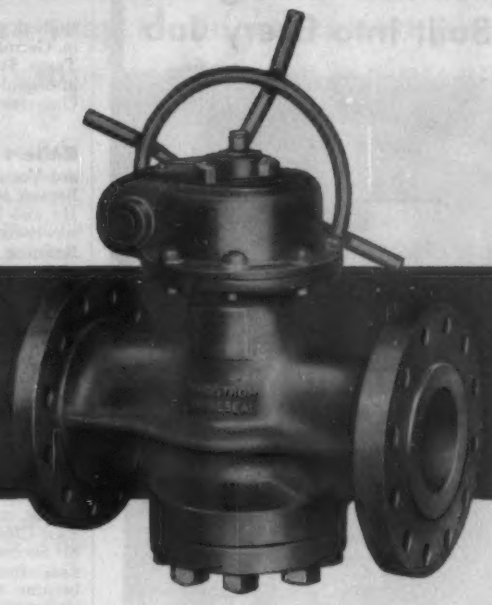

WHY REPLACE YOUR
LEAKING, TROUBLESOME
VALVES WITH THE SAME
TYPE YOU HAVE TAKEN
OUT?

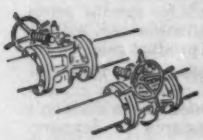
get permanent valve replacement



SPECIFY ROCKWELL-Nordstrom VALVES

Valve replacement programs are costly at best. Why replace your leaking, troublesome valves with the same type you have taken out? Insure permanent valve replacement with Rockwell-Nordstrom lubricated valves.

By replacing with Rockwell-Nordstrom valves, engineers in the gas, oil and process industries have found they can cut maintenance replacement costs *and* get better flow control in the bargain. Here are just a few reasons why they will stay in service longer, work better and cost less to use . . .



EASY REPLACEMENT:

Conformance to standard lengths means no piping revision. Replacement is fast and easy.

QUARTER-TURN CLOSURE:

No bulky bonnet to damage by impact . . . closes with a lubricant-smooth 90° turn.

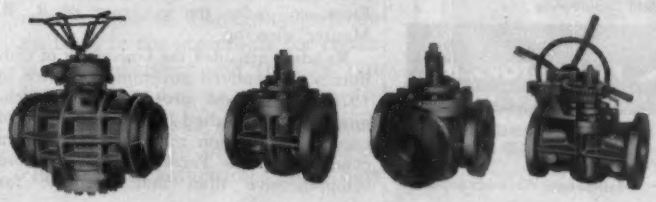
LEAK-PROOF:

Instantly replaceable "soft seats" of pressurized lubricant insure positive shut-off.

LUBRICATED:

Lubrication is preventive maintenance . . . less wear means less repair . . . lower costs.

Rockwell-Nordstrom is the world's *most complete* line of lubricated plug valves, plug valve lubricants and accessories. Rockwell-Nordstrom valves cost no more to buy, often less, than ordinary valves. In new construction or valve replacement, they'll give you better flow control and save you money everywhere you use them. For details, see your supplier or write: Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Valve Licensee: Peacock Brothers Limited.*

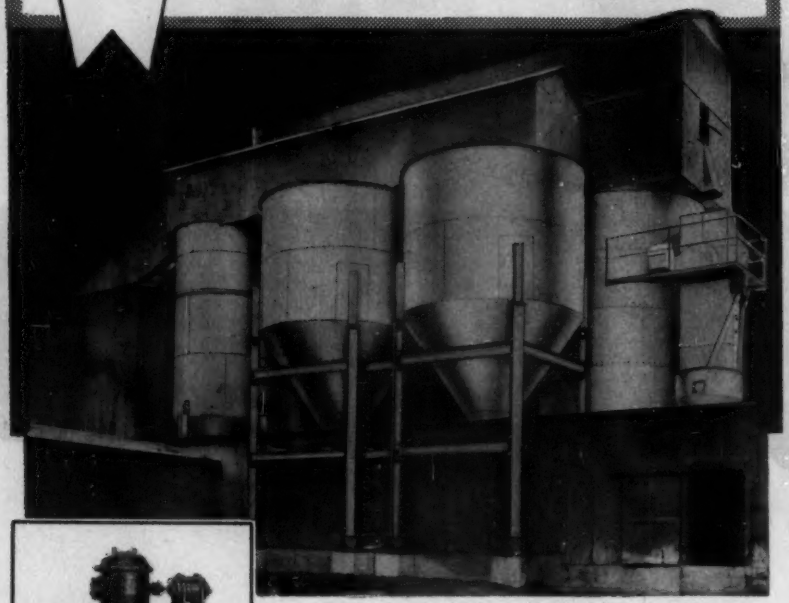


ROCKWELL-Nordstrom VALVES

it's ROCKWELL

MANUFACTURING COMPANY

77 Years of Koven Fabricating Experience Built Into Every Job

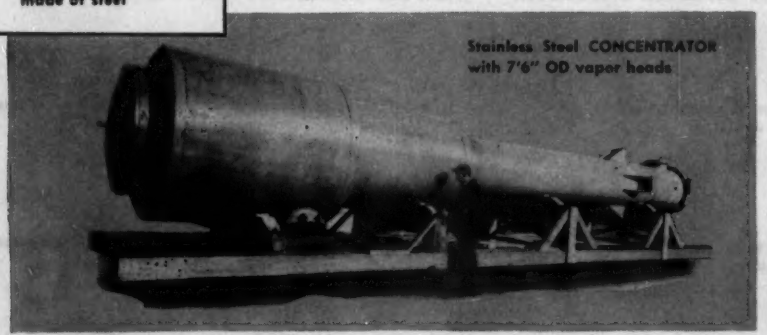


Field erected storage bins Stainless Steel Clad

Jacketed mixing Kettle made of steel

X-RAY INSPECTION FOR QUALITY CONTROL

KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; high vacuum testing.



Stainless Steel CONCENTRATOR with 7'6" OD vapor heads

SPECIALISTS IN INTRICATE FABRICATION USING:

STAINLESS STEEL • ALUMINUM • MONEL • NICKEL • INCONEL • ALL CLAD MATERIALS • NICKEL PLATED STEEL

Fabrication to all A.S.M.E. Codes
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80 ft. dia. Clarifying Tank—Field Erected

Koven FABRICATORS, INC.
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Call or write for a consultation with a trained KOVEN representative, and send for Bulletin #550. Members of Steel Plate Fabricators Association.

PLANTS:
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Men in the Industry . . .

studied with I. G. Farben Industries A. G. in Germany. Mark graduated from North Texas State College with an M.S. degree in organic chemistry, and attended Indiana University graduate school, 1948-1952.

Robert E. Pulver is manager of Standard-Vacuum Oil Co.'s new $33.5 million Bataan refinery project in the Philippines. He also has been elected a director of the newly-formed subsidiary, Standard-Vacuum Refining Corp. (Philippines) which will operate the plant.

He began his duties at Manila on January 20, taking charge of pre-construction activities.

Pulver

Pulver is a graduate of Purdue University where he received his mechanical engineering degree in 1934. He has had 21 years' experience in the oil industry mainly at the East Chicago Refinery of Socony Mobil Oil Co., Inc., where he became chief refinery engineer in 1948.

Since joining Standard-Vacuum in August 1955 as a supervising engineer in the Refining Coordination division, Pulver has been closely associated with the Bataan refinery project and, in general, with the development of plans for other new refineries and refinery components.

Matthew S. McCauley of St. Louis, director of business research for Monsanto Chemical Co.'s Organic Chemicals division here, has been appointed director of marketing research for the division.

McCauley will be responsible for continuing study of marketing conditions as applied to the products of the division, for analyses of market trends for specific products, and for the evaluation of market potentials as a basis of product sales plans.

McCauley joined Monsanto in 1929 and served in research and production capacities before being appointed as the division's director of business research in January, 1954. He holds a B.S. degree in chemical engineering and an M.S. degree in engineering administration from Washington University.

Edward T. Knudsen, who for many years has supervised the petroleum economics activities of the Department of the Interior on the Pacific Coast, has retired.

The monthly surveys, known in the petroleum industry and financial circles as "The Petroleum Situation in Pacific Coast Territory" and the "Petroleum Demand" report, prepared under the supervision of Knudsen, will be continued in the Region II office of the Bureau of Mines in San Francisco under the guidance of R. B. Maurer, director.

Knudsen attended the University of California and entered government service in 1926. He devised procedures and techniques which resulted in the production of current information relating to petroleum conditions in the Pacific Coast area more comprehensive than that available for

Trapping Standardization

. . . steam trap standardization plus standardized hook-ups spell lower maintenance costs

An important weapon in the fight against rising maintenance costs is standardization. It can reduce the variety of maintenance problems and simplify those which remain.

Since we specialize in steam traps we'd like to offer some suggestions for a trapping standardization program. Such a program involves standardization on one make of trap and standardization of hook-ups.

Trap Standardization

The advantages of standardizing on a single make of trap are important and can make a big difference in the cost and ease of repairs because—

1. You can carry a more complete stock of repair parts with a smaller inventory.

2. Maintenance personnel has the opportunity to become expert on one make rather than be "jacks of all traps."

3. As an exclusive user of one make of traps you become a preferred customer of your trap representative and can be sure of getting the best possible service.

4. You can enjoy the advantages of standardized hook-ups.

Standardized Hook-ups

Standardized hook-ups facilitate and reduce the cost of both original installation and maintenance. By adopting standards for the dimensions of all fittings, including nipples, each hook-up for a given size of trap is identical and can be fabricated in the pipe shop.

Unions should be used so that when a trap needs repair, the unions can be uncoupled, the trap lifted from the line and a spare carrying identical length nipples and half unions slipped into place. In as little as a minute or two a faulty trap can be replaced. The faulty trap can go back to the storeroom for repair when convenient and then be put into stock as a spare.

Figure 1 shows a typical standardized hook-up used by a major chemical manufacturer. Note how

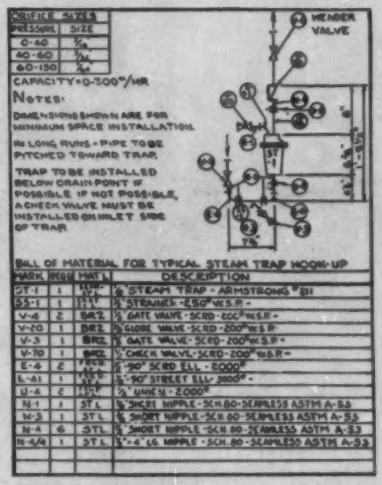

ORIFICE SIZES
PRESSURE | SIZE
0-60 | 7/64
60-150 | 1/4
CAPACITY=0-500#/HR
NOTES:
DIMENSIONS SHOWN ARE FOR MINIMUM SPACE INSTALLATION.
IN LONG RUNS - PIPE TO BE PITCHED TOWARD TRAP.
TRAP TO BE INSTALLED BELOW DRAIN POINT IF POSSIBLE. IF NOT POSSIBLE, A CHECK VALVE MUST BE INSTALLED ON INLET SIDE OF TRAP.
HEADER VALVE
DRAIN
BILL OF MATERIAL FOR TYPICAL STEAM TRAP HOOK-UP
MARK | SIZE | PART No. | DESCRIPTION
ST-1 | 1 | STM | 1" STEAM TRAP - ARMSTRONG #81
SS-1 | 1 | STRV | 1" STRAINER - 150# WS.P. -
V-6 | 2 | BRZ | 1/2" GATE VALVE - SCRD - 200# WS.P. -
V-20 | 1 | BRZ | 1/2" GLOBE VALVE - SCRD - 200# WS.P.
V-3 | 1 | BRZ | 1" GATE VALVE - SCRD - 200# WS.P. -
V-70 | 1 | BRZ | 1" CHECK VALVE - SCRD - 200# WS.P. -
E-6 | 2 | MAL | 1/2" - 90° SCRD ELL - 2000#
L-41 | 1 | MAL | 1" - 90° STREET ELL - 2000# -
U-6 | 2 | MAL | 1/2" UNION - 2000#
N-1 | 1 | STL | 1/2" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-3 | 1 | STL | 1" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-4 | 6 | STL | 1/2" SHORT NIPPLE - SCH 80 - SEAMLESS ASTM A-53
N-4/4 | 1 | STL | 1/2" x 4 LG NIPPLE - SCH 80 - SEAMLESS ASTM A-53

Fig. 1—Typical standardized installation hook-up used by a leading chemical manufacturer.

the hook-up provides the following advantages:

1. Test valve in trap cap permits fast, easy checking of trap operation.
2. Strainer ahead of trap protects it against dirt and scale.
3. Blowdown valve in strainer provides easy cleaning.
4. Check valve in discharge line isolates trap when test valve is opened.
5. Shut-off valves and unions ahead of and following trap permit removal of entire trap from line.

Another important consideration for getting the most from a standardization program is accessibility of the traps. Insofar as is possible, traps should be located so that they are convenient for inspection. The easier it is to locate and get at a trap, the less likelihood that it will be overlooked.

Fig. 2—Armstrong traps have only two moving parts—the lever assembly and the bucket. Nothing much to go wrong here.

What Make of Trap? (This is the Commercial)

Obviously, a trap standardization program shows the best results when the make of trap selected is the one that gives the best service. Naturally, we think the make should be Armstrong and fortunately a lot of trap users agree. Here are some of the advantages of standardizing on Armstrong that have been pointed out by these users:

1. *Armstrong traps work.* They don't leak steam and they do discharge condensate and air as fast as they reach the trap. And they work with any return system.

2. *Armstrong traps aren't "prima donnas."* They need no special care or coddling. Valve and seat are hardened chrome steel. Lever assembly and bucket are stainless steel and these are the only moving parts.

3. *Armstrong traps aren't "orphans."* You can *always* get parts and service from nearby Factory Representatives and stocking distributors.

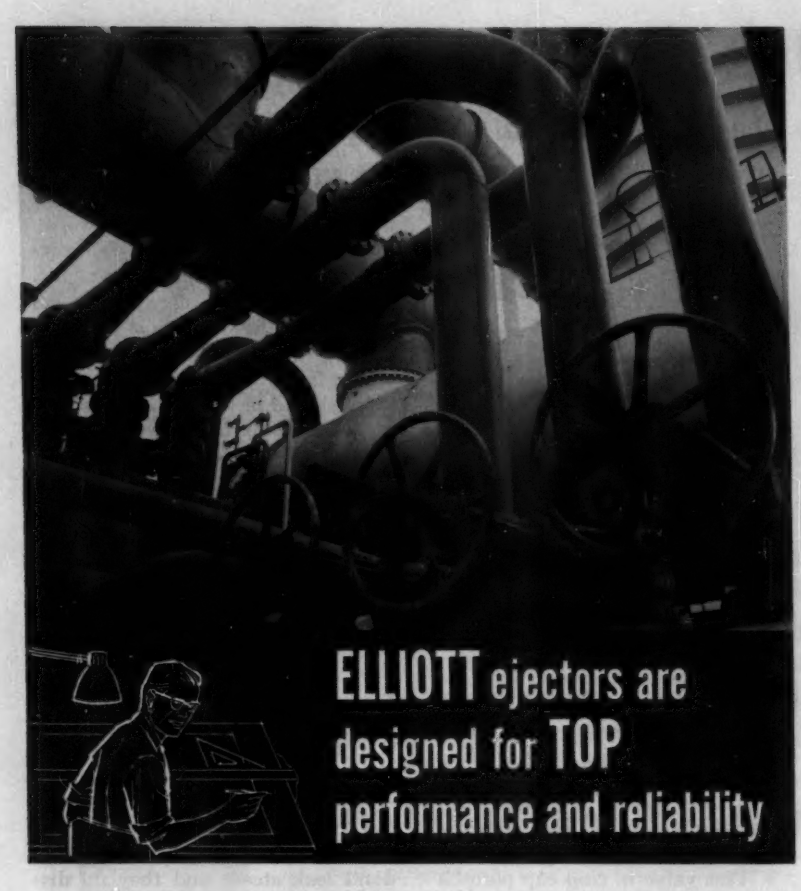
4. *Armstrong traps are guaranteed.* If you're not *completely* satisfied you can return the traps for refund of purchase price.

More Information

The 44-page Steam Trap Book (free on request) gives a lot more facts on trap selection and installation. Call your local Armstrong Representative or write **Armstrong Machine Works, 8522 Maple St., Three Rivers, Michigan.**

ARMSTRONG STEAM TRAPS

For more data on advertised products, use Readers' Service Cards, last page.



. . . engineered and built to meet your requirements

An unusual example of Elliott's engineering experience in designing and building steam jet ejectors and auxiliary equipment for producing vacuum is seen above. This photo shows the three first-stage ejectors of an Elliott triple element two-stage unit which serves a residuum stripper in a California oil refinery.

The vapor load from this vacuum flash unit adds up to approximately 57,000 lb per hr of steam, condensable hydrocarbon vapor and noncondensable gas. To handle this load efficiently and economically requires maintaining approximately 2 in. Hg absolute pressure *continuously*. Two Elliott 11,000-sq ft surface condensers are used, arranged in parallel, and the Elliott triple, two-stage ejector which serves these condensers is discharged to an intercondenser and an aftercondenser combined in a common shell.

wide range of single-stage and multistage types

of Elliott steam jet ejectors is available for maintaining low absolute pressures in refineries, chemical plants and other processing industries. For complete data or engineering assistance, call the Elliott ejector specialist at your nearby Elliott District Office, or write Elliott Company, Jeannette, Pa.

ELLIOTT Company

GB-1

Men in the Industry . . .

other sections of the United States. Under the Petroleum Code, which was operative during the NRA. Knudsen as Special Agent of the Petroleum Administrative Board, formulated the statistical procedure for the equitable allocation of district crude oil production quotas in California. During World War II he was consultant to Economics Committee of the Petroleum Administration for War and supervised the collection of their statistics.

Knudsen was honored by his associates in government and business at functions in San Francisco, Los Angeles and in San Rafael, where he now resides. He is an associate member of the Society of Petroleum Engineers, A.I.M.E., The American Statistical Association and the Native Sons of the Golden West.

Theodore E. Casselman, Jr. has been named an assistant engineering manager of Stone & Webster Engineering Corp. Also, **Normal L. Foskett,** chief process engineer since 1952, has been appointed chief engineer of the chemical division, and **Stanley B. Zdonik** has been named chief process engineer succeeding Foskett.

After graduating from MIT, Casselman was employed by Worthington Pump and Machinery Corp., Jackson Engineering Corp. and American Locomotive Co., before joining Stone & Webster in 1940.

Foskett is a graduate of the Colorado School of Mines, and prior to joining Stone & Webster in 1941, worked for Tidewater Oil Co., E. I. du Pont, and Standard Oil Co. (New Jersey).

Zdonik, a graduate of Massachusetts Institute of Technology, remained there for a year as an instructor in chemical engineering before joining E. B. Badger & Sons Co. which was merged into Stone & Webster in 1951. Since then he has been in process engineering for a wide variety of chemical and petroleum plants.

P. Craig Livesay has been named manager of Standard Oil Co.'s Sugar Creek, Mo., refinery. He will succeed **Harold R. Boehmer** who has retired.

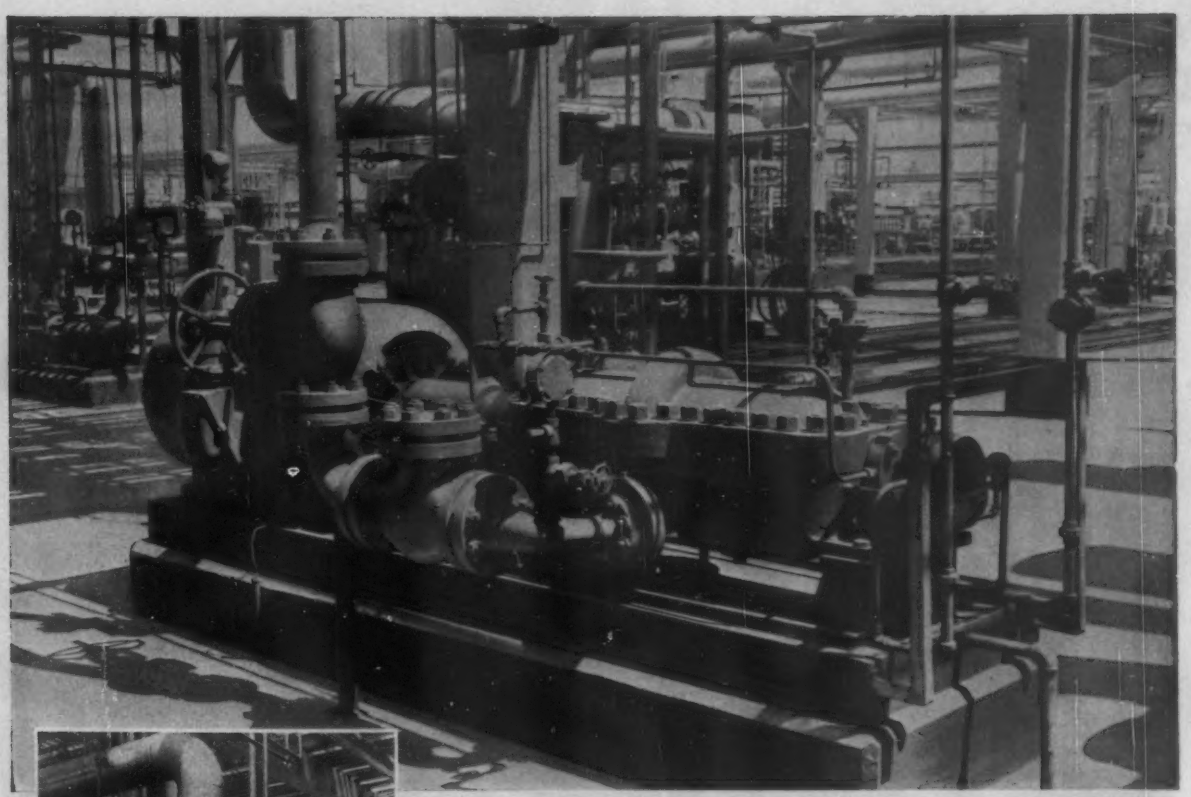
Harry G. Schnetzler, assistant refinery manager at Neodesha, will succeed Livesay, who has been with Standard since 1937 when he was employed as an engineer. He was transferred in 1953 to the Sugar Creek refinery where he became assistant manager early in 1956. In 1956 he became manager of the Neodesha refinery. He has a B.S. degree in civil engineering from Iowa State College and a M.S. degree from Texas A & M College.

Boehmer began his career at the Whiting refinery in 1915. He became superintendent of the Sugar Creek refinery in 1920, general superintendent in 1946, and manager in 1949.

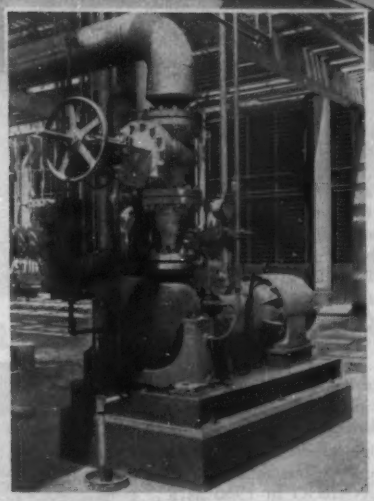
Schnetzler has been assistant manager at Neodesha since 1942. He joined Standard in 1924 as a chemist at the company's Whiting laboratory. He was transferred to Neodesha in 1932 where he became chief chemist in 1938, a post he held until 1949 after being named superintendent in 1942.

Norman D. Koch has been promoted to senior design engineer at Union Oil Co., of California's Research Center, Brea, Calif. Other promotions in the California Research Center were: Dr. W. D. Schaeffer and Dr. C. R. McEwen to section leaders.

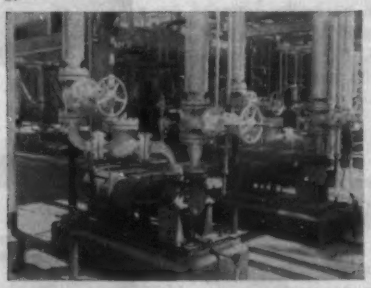
For more data on advertised products, use Readers' Service Cards, last page.



Ingersoll-Rand 200-hp Class CNTA reactor charge pump for Rexforming Unit at Cosden Refinery, handling gasoline at 195 gpm.



Ingersoll-Rand Class HFL extractor charge pump handling hydrocarbon liquid at 200 gpm.



Two Ingersoll-Rand Class SFL pumps for No. 2 tower, handling hydrocarbon feed stock at 80 gpm.

CHARGE PUMPS

at Cosden Rexformer Unit

Ingersoll-Rand Centrifugals put the pressure on high-octane gasoline production at Texas refinery

THE Ingersoll-Rand pumps shown here, handling hydrocarbon charge stocks, are but four of the *thirty* I-R pumps serving the new U.O.P. designed Rexformer Unit at the Big Spring Refinery of Cosden Petroleum Corporation.

These charge pumps, operating at pressures up to 700 psig, are vital to the entire reforming process. Any failures here could shut down the entire unit. That's why the traditional *dependability* of Ingersoll-Rand pumps is a big asset. Their sustained high efficiency and low maintenance are important *economy* factors, too.

The complete I-R line of centrifugal pumps covers every refinery or process plant application, in types, sizes and capacities to meet every requirement to best advantage. To solve your pumping problems *fast*, just call your nearest I-R Branch Office.

Ingersoll-Rand

10-692

11 Broadway, New York 4, N. Y.

PUMPS • COMPRESSORS • DIESEL ENGINES • AIR & ELECTRIC TOOLS • TURBO BLOWERS • CONDENSERS

What Suppliers Are Doing . . .

Selover

Charles W. Selover has been named manager of purchases for Hooker Electrochemical Co. plants at Niagara Falls and North Tonawanda, N. Y.

Selover has been purchasing agent for raw materials at Hooker since February, 1956, when he was transferred to Niagara Falls from the Durez Plastics division, North Tonawanda, following the merger of Durez into Hooker the previous year. He started his business career in 1929 in the accounting department at Durez. Appointed assistant treasurer and credit manager in early 1937, he held this position until 1947 when he became purchasing agent for Durez.

Crocker

John W. Crocker, a member of the Mechanical division staff of Stone & Webster Engineering Corp. has been named manager of the Stone & Webster district office in Houston.

Crocker has worked in the design and construction of pulp and paper mills, and has had experience in consulting work on power plants and the engineering and erection of various industrial facilities. He received a degree in mechanical engineering from Edinburgh University, Scotland.

Seaton

Ralph Seaton has been appointed to the newly created post of technical sales supervisor for Wolverine Tube, fabricating division of Calume & Hecla, Inc.

Seaton will be responsible for the sales of Wolverine heat transfer products to the oil and chemical industries, public utilities, and to concerns working on nuclear power projects.

Formerly technical sales representative in the New York-New England areas, Seaton will make his headquarters in Wolverine's new administrative offices in Allen Park, Mich.

Krieg

Charles D. Krieg of the Tretolite Co. division of Petrolite Corp. service and development laboratory in St. Louis, has been assigned to Houston to carry on liaison work of field to the central research and development program.

He succeeds **Ed A. Baumstark,** who recently was appointed assistant to **L. A. Bainter, Jr.,** manager of the Southern division.

Brisman

T. D. Brisman has been appointed manager of sales, Houston district office of National Tube division, United States Steel Corporation. He succeeds the late **James R. Boax.**

Brisman returns to the office where he started his business career, all with National Tube, 19 years ago. He is an engineering graduate of the University of Minnesota.

Starting in the Houston office in February, 1939, he transferred to San Antonio later that year as resident salesman serving South Texas and the Southern Gulf Coast. After military service in 1945 he was a resident salesman in Amarillo. In 1953, he was promoted to manager of claims of National Tube division and in 1955, was made special representative, oil and gas industry, New York.

Temple

Joseph M. Temple has been appointed manager of a new sales region established in the Rocky Mountain area by The Foxboro Co., Foxboro, Mass., to provide direct and immediate attention to the instrument needs of industry throughout the Rocky Mountain region. Temple, with headquarters at Denver, will supervise Foxboro branch offices in Denver, Salt Lake City, Kansas City and Omaha.

Educated at Louisiana State University, Temple is widely experienced in industrial instrumentation, having served as manager of the Baton Rouge and Houston offices since joining Foxboro in 1949.

Luetzow

Howard J. Luetzow has been named technical sales representative to serve the New York, New England areas for Wolverine Tube, Division of Calumet & Hecla, Inc. He replaces **Ralph Seaton** who becomes technical sales supervisor in Wolverine's general sales offices.

Formerly technical sales representative in Wolverine's Midwestern Sales District, Luetzow will contact petroleum, petrochemical, chemical companies and heat exchanger manufacturers and fabricators.

Keech

Horace Keech has been named plant manager for Conoflow Corp., a manufacturer of final control elements.

Keech will assume full responsibility for line supervision of the company's production and affiliated plant operations. He has had extensive experience in metal products manufacturing at various managerial levels. Immediately prior to joining Conoflow late in 1957, Keech spent eight years as chief engineer and assistant plant manager of the C. Howard Hunt Pen Co. in Camden, N. J. He is a graduate of Massachusetts Institute of Technology.

Plummer

Erle T. Plummer has been named general sales manager of the Union Asbestos & Rubber Co.'s Fibrous Products division.

Plummer began his business career with the Wells Fargo Bank in San Francisco in 1939. He joined UNARCO in 1950 as a sales representative for the Fibrous Products division in the San Francisco office and later served in a similar capacity in the company's Houston office.

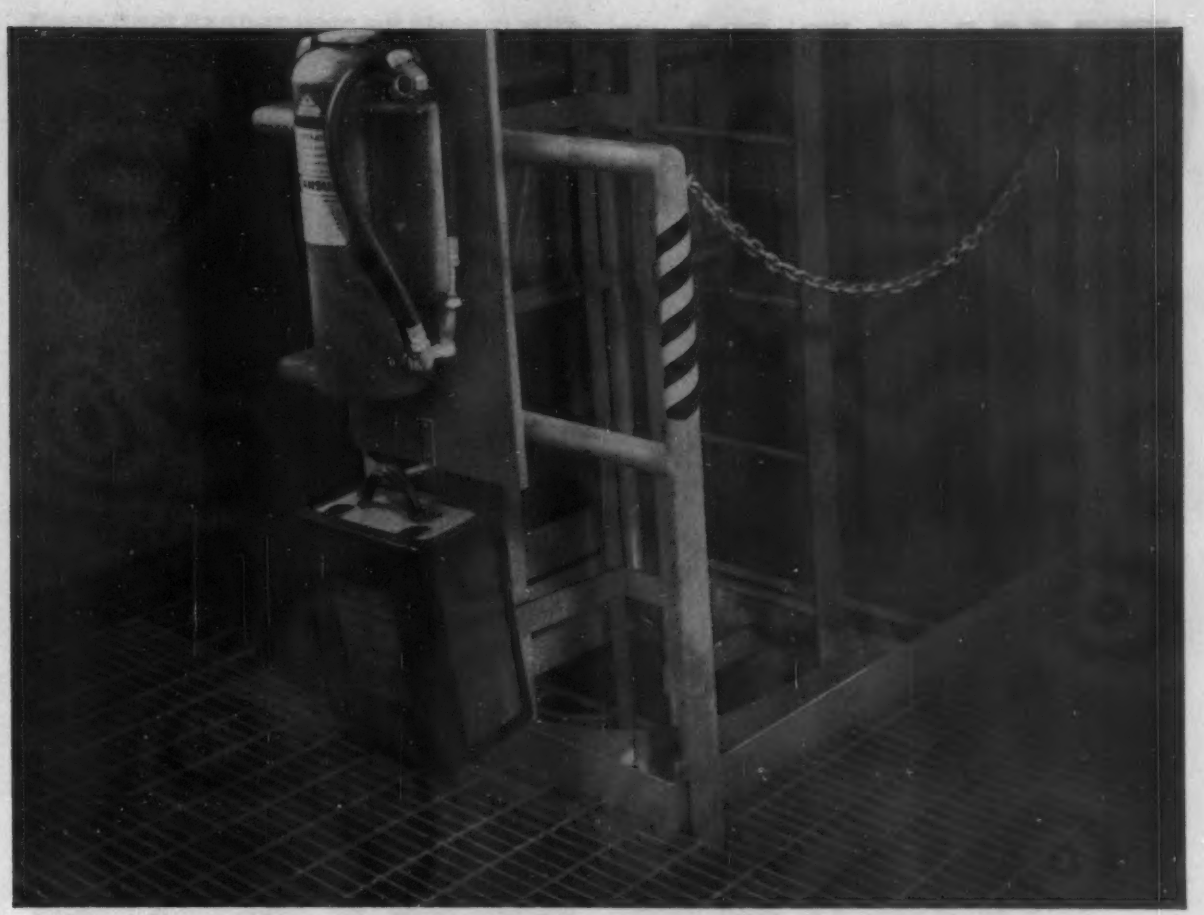
In March, 1955, he was promoted to assistant general sales manager with headquarters at the company's Bloomington, Ill., plant.

Austin

Edmund C. Austin has been appointed to the newly created position of director of purchases for The Fluor Corp., Ltd.

Austin, who was graduated from the University of Southern California in 1931 with a B.A. degree, has over 20 years of experience in purchasing and related fields with Standard Oil Co. of California, and Arabian American Oil Co.

Following his graduation, he worked as a clerk in a Standard Oil subsidiary. In 1935, he moved to that firm's purchasing



A dangerous place to work...

that's why you see so many symbols of safety

Here's a plant that's out to keep "employee downtime" at a minimum. Extinguishers and gas masks provide protection against fire and toxic fumes. Guard rails and chains surround permanent hazards. Raised steel strips around floor openings prevent objects rolling or being kicked to the floor below. Clean windows and bright lighting provide good visibility. It's only natural that a company so interested in safety should select Blaw-Knox Electroforged® Steel Grating for "underfoot" safety.

Each section of Blaw-Knox Steel Grating is of rigid, one-piece construction. Choice of cross bar and bearing bar designs and spacings affords maximum safety under all working conditions. Indoors or out, you get safe, quiet, long lasting and self-cleaning flooring with maximum passage of light and air.

Blaw-Knox Electroforged Steel Grating is fabricated in a wide selection of materials to exact customer specifications. Fits easily and neatly into even the most congested areas.

Send for new Blaw-Knox Grating Catalog 2527. See new ideas in flooring, walkways, stair treads, platforms, shelving. Write today.

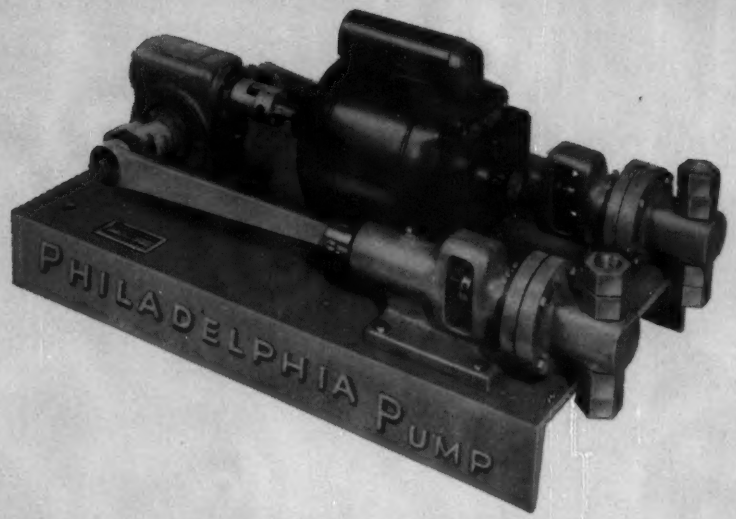
BLAW-KNOX

BLAW-KNOX COMPANY

Blaw-Knox Equipment Division · Dept. D, Pittsburgh 38, Pa.

For more data on advertised products, use Readers' Service Cards, last page.

PHILADELPHIA



controlled capacity

PUMPS

Accuracy and low maintenance to meet fluid proportioning requirements in Chemical Processing, Refining and Boiler Feed Applications.

Philadelphia proportioning pumps feed precisely metered fluids or slurries into low or high pressure systems in nearly any desired ratio with flow, temperature, pressure, conductivity, PH and other controlled process variables. Control may be manual or automatic—with electric, hydraulic or pneumatic systems.

Models may be obtained to handle a great variety of "tough," corrosive and viscous materials. *Write for full information.*

PHILADELPHIA PUMP

Division of American Meter Co.

13500 Philmont Avenue, Philadelphia 16, Pennsylvania

High-Pressure Pumps • Controlled Capacity Pumps • Chemical Feed Systems

Suppliers . . .

department in San Francisco where he stayed until 1939 when he joined Aramco. He left the firm in 1955 as manager, materials supply and as a member of the management committee.

Prior to joining Fluor, he was petroleum adviser and assistant general manager of the Canadian Bank of Commerce in Toronto, Canada.

UNITED STATES STEEL CORP. announced that the request of **John A. Stephens,** vice president-industrial relations (that he be relieved of administrative responsibilities) has been honored. Stephens, who holds a B.A. degree from Columbia University and an honorary doctor of science degree from Wesleyan University, joined U. S. Steel in 1934 after fifteen years of industrial management responsibility. In 1943 he became vice president, director, and a member of the executive committee of United States Steel Corp of Delaware. When in 1951 the Delaware Corp. was merged with United States Steel Co., Mr. Stephens continued as vice president of industrial relations.

SOLAR-CHICAGO CO., a division of U. S. Industries, Inc., has appointed **James I. Julian** vice president of the company. He will be in charge of production, engineering and service for the company's two subsidiaries—Solar Permanent Co., and Chicago Steel Tank Co.

Julian joined the Solar Permanent Co. in 1957. Prior to that he was maintenance superintendent in the Chemical division of a pulp and paper mill.

THE AMERICAN INSTRUMENT CO. has appointed **Herman C. Zwart** as the company's second representative in California and 14th throughout the United States. His office will be at 1485 Bay Shore Blvd., San Francisco, Calif.

A graduate of Lehigh University in chemical engineering, Zwart has had experience in engineering, sales and sales promotion in industry and in the military. He will direct the sales activities of the entire Aminco line.

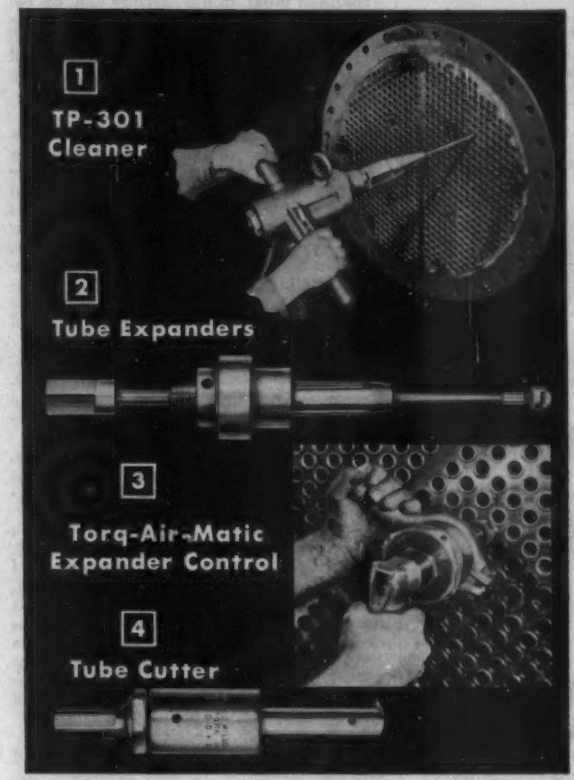
A. M. LOCKETT & CO., LTD., sales engineering representatives of The Babcock & Wilcox Co.'s Boiler division, has moved its district sales office to 1701 Mercantile Dallas Bldg., 1807 Commerce St., Dallas 1, Texas. The office was formerly located at 1826 Life of America Bldg. in Dallas.

THE HORTON CO. has made **William G. Fallon** vice president, director and executive board member of the firm at its 73rd annual meeting January 21. He was reappointed general manager of the company's Refractories division.

Fallon has been general manager of the Refractories division since it was established in September 1956. He graduated from Princeton University and attended the Harvard Graduate School of Liberal Arts. The 41-year-old executive joined Norton Co. in 1943 as a member of the manufacturing control department following three years as a teacher in secondary schools. He served as engineer of refractory products and staff engineer to the Plants Engineer. In 1951 he went to Johannesburg, South Africa, to be the first works manager of

Keep Heat Exchangers on stream with

WILSON
TUBE MAINTENANCE TOOLS



1 Heavy-duty TP-301 Cleaner is a positive air-driven, hollow rotary shaft, drill type tool. Tube is scavenged with air or water while cleaning.

2 Wilson Models 41 and 44 Tube Expanders incorporate an improved, adjustable ball bearing thrust collar and are designed for efficient, easy rolling and maximum roll length adjustment for various tube sheet thicknesses.

3 New Wilson Torq-Air-Matic is the first and only air-driven tube expander drive that accurately controls tube expansion by directly measuring torque output at the mandrel.

4 Wilson tube cutter is easy to use and does a fast job. Cutter sizes and shanks available to meet all heat exchanger requirements.

Write today for your copies of Wilson Tube Cleaner catalog No. 77 and Wilson Tube Expander catalog No. 88. TW-881

Representatives in principal cities
THOMAS C. WILSON, INC.
21-11 44th Ave., Long Island City 1, N. Y.
Cable address: "Tubeclean", New York

WILSON
TUBE CLEANERS • TUBE EXPANDERS

Why Is
RIDGID
The World's
Most Popular
Pipe Wrench

...because it was a better pipe wrench when first created 35 years ago, and nearly every year since it has been improved . . . in performance, design, materials, so it is still the most for your money. Buy RIDGID at your Supply House.

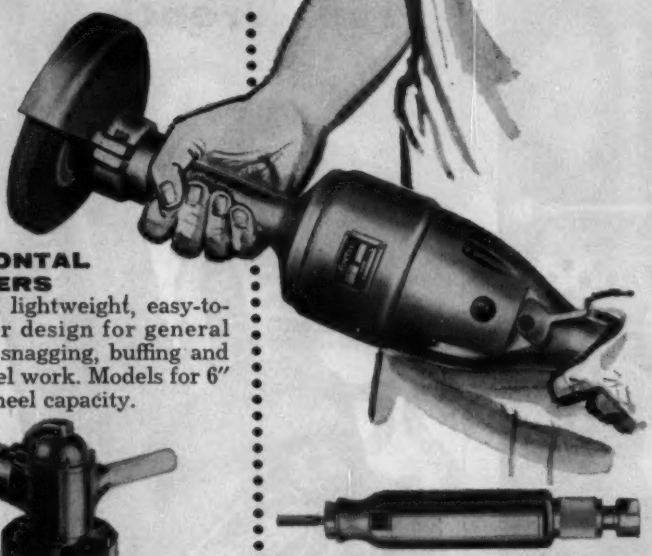
The Ridge Tool Company, Elyria, Ohio, U.S.A.

For more data on advertised products, use Readers' Service Cards, last page.

AIRETOOL

pneumatic tools increase output . . . cut production costs

Reduce grinding, sanding and drilling costs with these versatile, easy-to-operate production tools powered by Airetool's dependable pneumatic motor.



HORIZONTAL GRINDERS
Balanced, lightweight, easy-to-maneuver design for general grinding, snagging, buffing and wire wheel work. Models for 6" and 8" wheel capacity.

VERTICAL GRINDERS
The perfect tool for cup wheel grinding on flat or curved surfaces. May be equipped with wire brush or sanding disc. Models for 6" abrasive wheel and 7", 8" or 9" disc wheel.

MIDGET DIE GRINDERS
Performs the most intricate precision grinding, filing and cutting jobs quickly and easily. Two models: 38,000 and 60,000 RPM with either 1/8" or 1/4" chuck.

HEAVY DUTY DRILL
A rugged tool for speedy production or general maintenance drilling. Effective lubrication system insures long trouble-free service. Equipped with self-centering 3/4" 3-jaw chuck.

LIGHTWEIGHT DRILLS
Compact, easy-to-handle design for fast, accurate production drilling. Models with 3/16", 5/32", 1/4" chuck capacities and full range of speeds.

WRITE FOR CATALOG NO. 63 containing complete, detailed information on all Airetool Pneumatic Tools and accessories.

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

BRANCH OFFICES:
New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge.

REPRESENTATIVES: in principal cities of U.S.A., Canada, Mexico, Puerto Rico, South America, England, Europe, Italy, Japan, Hawaii.
EUROPEAN PLANT: Vlaardingen, The Netherlands.
CANADIAN PLANT: 37 Spalding Drive, Brantford, Ontario.

Suppliers . . .

the most recently built Norton overseas grinding wheel plant.

RUST OLEUM CO.'s two-year $600,000 plant expansion program was recently announced. New production facilities in the manufacturing division include a three-story, 12,000 square foot warehousing unit, new ball mill equipment, and a new automatic packaging system.

LION OIL CO. has appointed **Donald J. Fox** manager of the company's asphalt sales. Fox was graduated from Kansas State College in 1934 with a B. S. degree in industrial chemistry. Since then he has been in various phases of the asphalt business, except for three years in the U. S. Air Force. He has been manager of the asphalt department for Derby Refining Co. of Wichita, Kan., since 1952. He will replace **Robert E. Witt** who has been manager of asphalt sales since 1956.

CRANE CO. has appointed **William O. Brown** general manager of sales on the West Coast with headquarters at the Chicago general office.

Brown will coordinate the plumbing, heating and industrial sales activities, as well as the marketing research and advertising-sales promotion departments.

Brown has been district manager with headquarters at Los Angeles since 1954. From 1950 to 1954 he was manager of Crane Co.'s plumbing sales department, Chicago. He joined the company in 1930 at its Washington, D. C. branch. He was named assistant branch manager there in 1943 and later became sales manager. In 1946 he was promoted to the managership of Crane's Richmond branch, a post he held until moving to Chicago in 1950.

UNITED STATES STEEL CORP. has named **Edward H. Pelster** manager of sales of the Tulsa sales office of National Tube division. Pelster succeeds Gerald F. Coons who is retiring. Pelster began his career with National Tube as an office boy in the St. Louis sales office. After serving as an order clerk and salesman there, he was transferred to Tulsa in 1931 as a salesman and served National Tube customers in Tulsa and Houston until 1954, when he was made manager of sales of National Tube's Denver, Colo., office.

Jake Easton, Jr., who has been a salesman in the Tulsa district for National Tube, will succeed Pelster as manager of sales at Denver. Easton is a graduate of the University of Oklahoma. He started with National Tube in the Tulsa sales office after graduation and with the exception of five years military service has spent his entire business career with National Tube at Tulsa and Wichita, Kan.

JONES & LAUGHLIN SUPPLY DIVISION today announced two changes in the management of J&L stores.

R. E. Holbrook, formerly local store manager at Lafayette, La., has been transferred to the Houston store in the same capacity.

B. M. Ferriss, formerly storeman advanced at Houma, La., is promoted to local store manager at Lafayette.

NORTON CO. has appointed **William F. Watts** factory manager of the Refractories division. He was formerly factory superintendent of the division.

Watts joined Norton Company in 1935

BRIEFS for buyers of Caustic Soda Caustic Potash

Useful facts on buying caustic soda are at your fingertips in this new pocket-size booklet.

Title: *Caustic Soda Buyer's Guide.*

Contents include a list of reasons *pro* and *con* switching from 50% to 73% liquid caustic.

There's a factual discussion of the comparative economics of both strengths, including a handy nomograph to help you figure which strength is your better buy.

The booklet also contains a nomograph that helps you estimate your liquid caustic requirements for various process solutions.

There's information on solid and flake caustic, too. Two tables show at a glance the dimensions and capacities of the many containers in which you can buy Hooker caustic soda.

Finally, there's a list of important points to consider when you're looking for a caustic soda supplier.

Check the coupon at right for a copy. Or write us if you'd like more than one.

KOH and NaOH

you save with a single source

One order. *One* billing. *One* responsibility. That's how you save time and cut paper work by getting both caustic soda and caustic potash from a single source, Hooker.

Order them together. Get them together.

To keep your file current on the forms, strengths, and specifications for NIALK® caustic potash, send for new data sheet:

Liquid: 45% to 52%, tank cars and drums.

Flake and Solid: 85% and 90%.

Special 90% forms: granular, broken, crushed, powder, and walnut.

Can you save buying by barge?

If you use large tonnages of 50% liquid caustic soda, and can receive by water, you may cut freight and handling costs substantially with barge service.

All Hooker plants and caustic terminals offer barge service as well as tank car service, since all are located on deep water.

If you think there's a possible saving here, one of our representatives will be glad to discuss barge delivery with you.

Which flake size? It's easy to be sure of the best possible caustic soda flake size for your process, when you buy Hooker caustic.

You have your choice of the four sizes here—all shown actual size.

Regular, fine, and *crystal* flake are

non-dusting—carefully screened for uniformity. We're extra-fussy about flake *thickness,* too. These flakes are hefty enough to take the jolts and jouncing of transit, and still reach you at full size. Yet they're thin enough to dissolve quickly when you're ready to put them to work.

For advice on the best flake size for your needs, write us, outlining the intended use.

For more information on chemicals mentioned on this page, check here:

- ☐ Caustic Soda Buyer's Guide
- ☐ Caustic Soda Data Sheet
- ☐ Caustic Potash Data Sheet
- ☐ General Products List

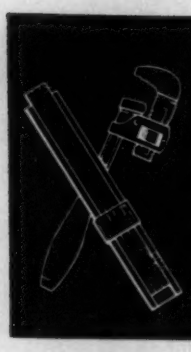
Clip and mail to us with your name, title, and company address.
(When requesting samples, please use business letterhead.)

HOOKER ELECTROCHEMICAL COMPANY
1603 FORTY-SEVENTH STREET, NIAGARA FALLS, N. Y.

Sales Offices: Chicago Los Angeles New York Niagara Falls Philadelphia Tacoma Worcester, Mass.
In Canada: Hooker Chemicals Limited, North Vancouver, B. C.

HOOKER CHEMICALS PLASTICS

For more data on advertised products, use Readers' Service Cards, last page.



YOU GET EVERYTHING THE ENGINEER & MAINTENANCE MAN ASKED FOR IN THIS NEW LIGHT WEIGHT, COMBINATION STEAM TRAP!

Fast warm up through rapid removal of both air and condensate up to 10° F. of saturation.

●

Continued discharge of air and condensate at steam temperature.

●

Built-in filtration of solids

●

Easy access to all working parts

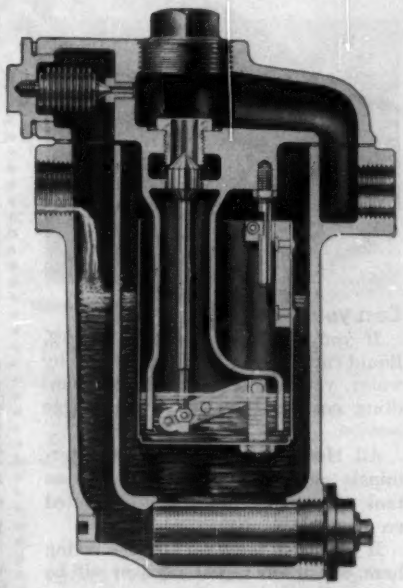
●

Interchangeable main orifice

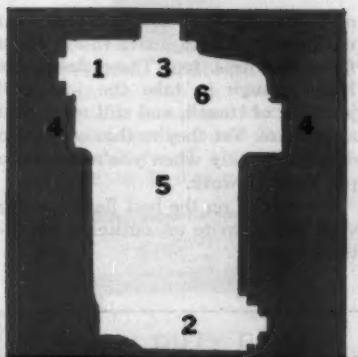
●

Light enough to be supported by line

Step by step steam traps have been improved, making them compact, lighter and more efficient, easier and faster to service. Now Wright-Austin has incorporated all these advances into one of their proven vertical bucket-type traps—the new 500-C series. Write for literature.



500-C Series—For ½" to 2" pipe lines; Pressures to 150 PSIG; Capacity to 30,000 lbs./hr.



1. Monel thermostat air by-pass
2. Monel strainer
3. Valve seat accessible through inspection plug
4. Straight-through pipe connections
5. All operating parts stainless steel
6. Working parts removed with cover

For fast and continuous heat in:

Unit heaters
Hot water heaters
Steam mains
Laundry equipment
Platen presses
Heat exchangers
Cylinder dryers
Jacketed Kettles
Sterilizers
Evaporators

WRIGHT-AUSTIN COMPANY
1894
3245 WIGHT STREET • DETROIT 7, MICH.

Suppliers . . .

following graduation from Northeastern University. He worked in the methods and manufacturing control departments and in 1950 was named assistant superintendent of the refractories plant. He became superintendent a year later.

NATIONAL AIROIL BURNER CO., INC., has announced that **John F. Straitz, Jr.,** has succeeded Edward P. Bailey as president of the company. Straitz has been with National Airoil since 1939, and is the son of one of the founders, J. F. Straitz, Sr. Bailey, president since 1928, will be retained as counsel to the firm.

HOOKER ELECTROCHEMICAL CO. has promoted **Edward W. Mathias, Arthur W. Chambers Jr.,** and **A. Richard Perry** to administrative positions it was announced by **Thomas E. Moffitt,** president. Mathias has been appointed assistant treasurer, Chambers named assistant secretary and associate counsel, and Perry made assistant comptroller.

Mathias received a B.S. degree in economics from the Wharton School of Finance and Commerce at the University of Pennsylvania in 1931. Following auditing and accounting experience Mathias joined Durez Plastics and Chemicals, Inc., becoming assistant treasurer in 1947 and treasurer in 1954. Following merger of Durez into Hooker in 1955 he moved to Hooker's headquarters at Niagara Falls.

Chambers, who has been assistant to the secretary and general counsel, was born in New Haven, Conn. He received his B.S. degree in 1939 and L.L.B. degree in 1942, both from Yale University. In Navy service he rose to lieutenant commander and from 1946-51 was a partner in the law firm of Chambers and Grimes in New Haven.

Perry, formerly assistant to the comptroller, attended Niagara University and the University of Illinois from which he received a B.S. degree in 1943. Between 1946 and 1948, Perry worked in the accounting department of Moore Business Forms, Niagara Falls, and from 1948 to 1956 was employed at Spirella Co. Inc., where he became controller. In 1956 he joined Hooker.

THE CARWIN CO. has announced the election of **Donald A. Bender** as vice-president by the board of directors.

Bender's duties will be broadened to include responsibility for the operations of the Company's chemical division. He is also corporate secretary and will continue to hold this office.

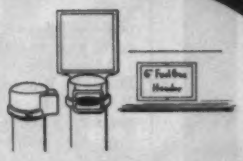
Bender holds a B.S. degree in chemical engineering from Lehigh University and an M.S. degree from Columbia University. He joined the Carwin Co. in 1950.

THE RAMO-WOOLDRIDGE CORP., Los Angeles, and **Thompson Products, Inc.,** Cleveland, announced jointly the formation of a new subsidiary corporation, to be known as **Thompson-Ramo-Wooldridge Products, Inc.**

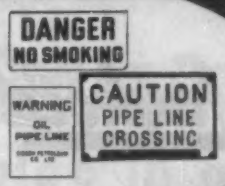
The new company will concentrate its efforts on industrial process control, and will market as its first major product, the RW-300 digital control computer. Installation of the first RW-300 is already underway for the Texas Co., Port Arthur, Texas, where it will be utilized to control a polymerization unit. In oil refinery operation the RW-300 can offer substantial savings in increased process through-

For more data on advertised products, use Readers' Service Cards, last page.

L&M Industrial
Plant Signs
Junction Boxes
Sole Distributors



L&M Dura-Glaze
Aluminum Plate
Safety Signs



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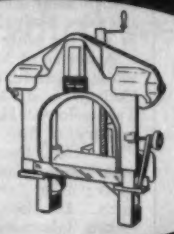
Guillotine Saws
National Saws
Agent for
E. H. Wachs Co.



- check valves
- torches
- pipe locators
- saddles and reducers

TOPAZ . . . LEADER IN ENGINEERING ASSISTANCE

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Pigging, Wedge-
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Topaz sales engineers will assist
your Engineering Department and supervise
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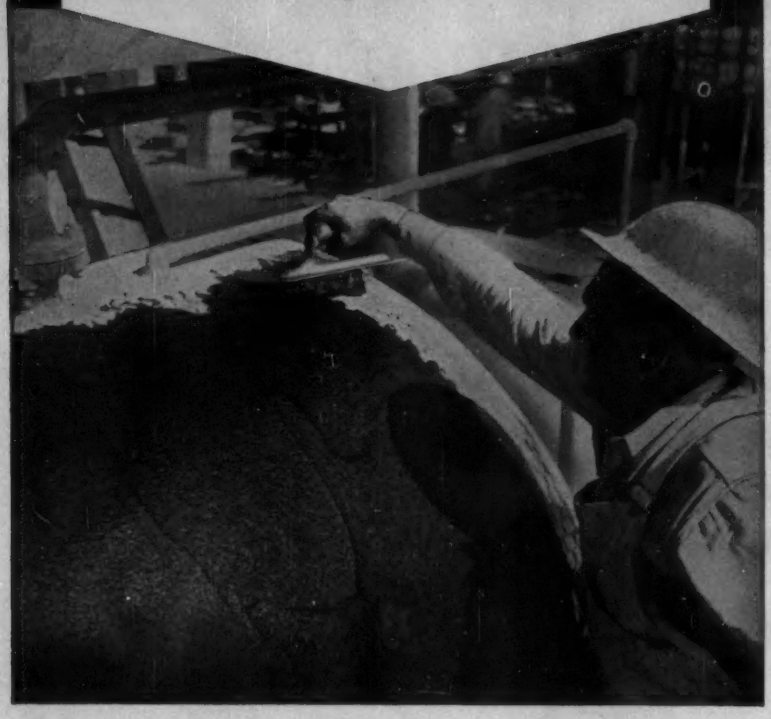
Laykold® WEATHERCOAT
protects exposed insulation



INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single*, thick layer.

Write today for free illustrated brochure, entitled "Laykold Weathercoat for Insulation Protection."

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Inglewood, Calif. · Oakland 1, Calif. · Tucson, Ariz.
Portland 7, Ore.

Suppliers . . .

put, improved yields, reduced operating costs and better product quality.

Management appointments include: **Dr. Dean E. Wooldridge**, president, **Dr. Joseph F. Manildi**, general manager; **Dr. Montgomery Phister, Jr.**, director of engineering; **Raymond E. Jacobson**, director of marketing; and **Robert J. Barrett, Jr.**, controller. Dr. Wooldridge will continue to serve as president of The Ramo-Wooldridge Corp.

UNITED STATES STEEL CORP. has appointed **J. C. Whetzel** manager of tin plate products, it was announced by **Richard F. Sentner**, U. S. Steel executive vice president—commercial.

He will succeed **George E. Totten** who retires after 21 years as head of tin plate sales for United States Steel and 47 years in the tin plate industry.

A native of Martinsburg, W. Va., Whetzel is a graduate of Washington and Lee College and Massachusetts Institute of Technology. He joined the research laboratory of the American Sheet and Tin Plate Co., then a subsidiary of United States Steel, in 1919, after a five-year career as a chemical engineer with other firms. He became manager of the research laboratory in 1922, and in 1932 was appointed assistant to the U. S. Steel vice president of operations, a post he held until he was named assistant manager of tin plate products in 1936.

GARDNER-DENVER CO. has put two new metallurgical laboratories into operation according to **G. V. Leece**, president. One will serve the plants located at the company's headquarters at Quincy, Ill., and the other is located at the Keller Tool division in Grand Haven, Mich.

The Quincy lab is under the direction of **Frank Harness**, chief metallurgist. The air-conditioned 64 by 90 foot building contains equipment for complete chemical and physical analysis of non-ferrous metals as well as steel and iron.

The Grand Haven lab, where **Claude Dierdorf** is chief metallurgist, is also equipped to analyze the physical and chemical properties of steel and cast iron.

VULCAN MANUFACTURING DIVISON, recently announced the appointment of two new representatives to Vulcan's field sales forces.

Paul Van Valkenburgh is now covering exclusively Oklahoma and the Texas Panhandle. He has been representing the interests of manufacturers in this area since 1951. Previously, he was associated with Continental Oil Co. and then the L. B. McKay Co.

The area of Minnesota, North Dakota, South Dakota and western Wisconsin is now being serviced by **Harley Turner.** Turner established his own business as a manufacturers' agent some 2 years ago.

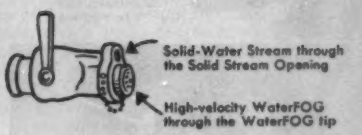
FISCHER & PORTER COMPANY has relocated its Chicago branch in a building especially constructed for its use at 1205 South 8th Avenue, Maywood, Ill. The one-story, fire-proof building covers 5700 square feet. Sales offices and a display area occupy 3000 square feet, the remaining 2700 square feet being alloted to warehouse and shop areas.

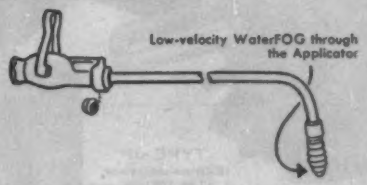
CONSOLIDATED ELECTRODYNAMICS CORP. has appointed **Monte L. Marks** chief development engineer of the Analytical and

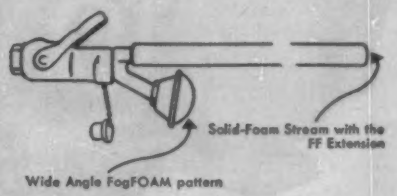
Rockwood WaterFOG Nozzle is five nozzles in one

The lightweight Rockwood SG-60 WaterFOG Nozzle *eliminates "special" or single-purpose nozzles!* It actually does the work of five nozzles to put out fires faster, safer and more economically.

Here's what we mean . . .







Here's what you need to put out ordinary combustibles and flammable liquids . . .

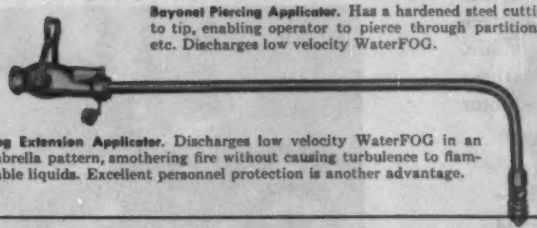
FOAM and "Wet" Eductor with the new FW Metering-Check Valve. Introduces Rockwood FOAM or "Wet" into hose lines, automatically proportioning correct amount of FOAM and "Wet" to water. Also usable wherever one liquid is fed into another on a fixed percentage basis.

Rockwood Double Strength FOAM. Puts out fires in flammable liquids, and in ordinary combustibles, quicker, at lower cost. Three parts FOAM and 97 parts water create a heat-resistant blanket.

Rockwood WET. One part WET mixed with 99 parts water increases water's penetration and extinguishing action. Gives quickest results against deep seated fires. Saves time, water, manpower.

FF Extension Unit. Shown with Type SG-60 Nozzle. Discharges Rockwood FOAM in a solid stream or as FogFOAM. Wide angle makes it possible to cover large areas at one time.

Bayonet Piercing Applicator. Has a hardened steel cutting tool attached to tip, enabling operator to pierce through partitions, into interiors, etc. Discharges low velocity WaterFOG.



Long Extension Applicator. Discharges low velocity WaterFOG in an umbrella pattern, smothering fire without causing turbulence to flammable liquids. Excellent personnel protection is another advantage.

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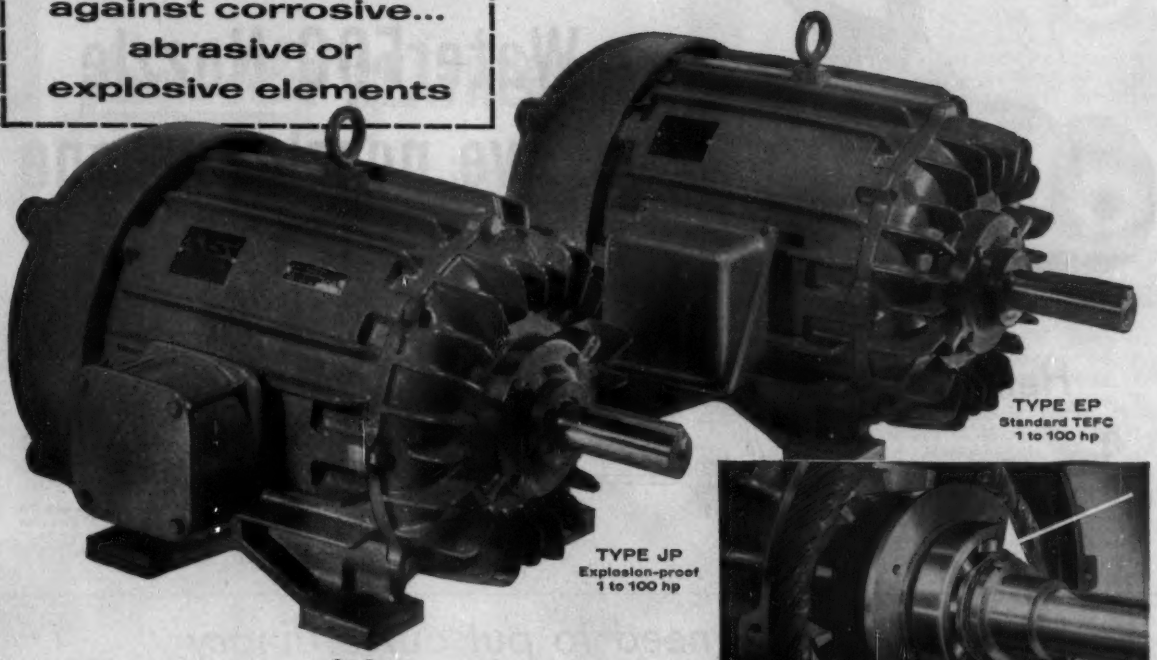
against corrosive...
abrasive or
explosive elements



TYPE EP
Standard TEFC
1 to 100 hp

TYPE JP
Explosion-proof
1 to 100 hp

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Wagner totally enclosed motors...protected for longer motor life

If you need motors that will keep production rates up . . . that will give the continuity of service that is so important to automation . . . that will operate with complete dependability under the most severe conditions—Wagner totally-enclosed motors are your soundest choice.

Type EP Motors offer protection against corrosion, dust, abrasives, fumes, steel chips or filings. Type JP is explosion proof as well—designed and approved for use in explosive atmospheres.

NEW NEMA FRAMES . . . These motors are built in the new NEMA Frame sizes from 182 through 445U, with ribs that add mechanical strength and increase the surface cooling area. Effective cooling system adds to motor life. Let your Wagner Sales Engineer show you how these protected motors can bring you savings on initial motor costs, maintenance costs and continuity of operation.

1 TO 100 HP—4 POLE, 60 CYCLE—
NEMA FRAMES 182 THROUGH 445U

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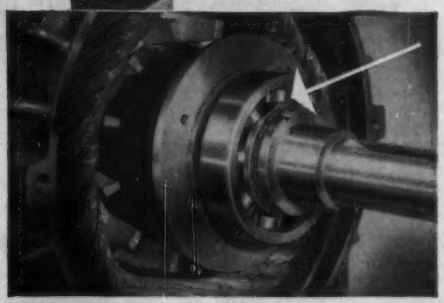


HEAVY DUTY BALL BEARINGS . . . The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long troublefree service under heavy loads.

BEARINGS CAN BE RELUBRICATED . . . Factory installation will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.

SEALS KEEP BEARINGS CLEAN . . . Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

Suppliers . . .

Control Instruments division, it was announced by **Harold F. Wiley**, director.

Marks joined CEC in 1951 after earning a B.S. degree in physics from the California Institute of Technology and an M.S. degree in electrical engineering from Stanford University.

He has held a number of engineering posts at Consolidated. Prior to his present appointment, he was a project engineer in the company's product engineering department.

JEFFERSON CHEMICAL CO., INC., has appointed **Joseph K. Goerner** as manager, Specialty Products, and **Ben C. Hayton** as manager, Glycol Products. Both men will report to the company's Marketing department.

Goerner was formerly assistant to the general manager of the Research and Development department. He joined Jefferson in 1946 after graduating from Rice Institute with a B. S. degree in chemical engineering. As manager, Specialty Products, he will be concerned with such chemicals as ethanolamines, morpholine, surface active agents and similar products.

Hayton has been assistant to the general manager of the Marketing department since 1956. He received his B. S. degree in chemical engineering from Rice Institute in 1945 and has been with Jefferson since 1946. As manager, Glycol Products, he will be concerned with ethylene, ethylene oxide and glycol products.

Both men will be responsible for technical service on products assigned to the other management responsibilities concerning their products.

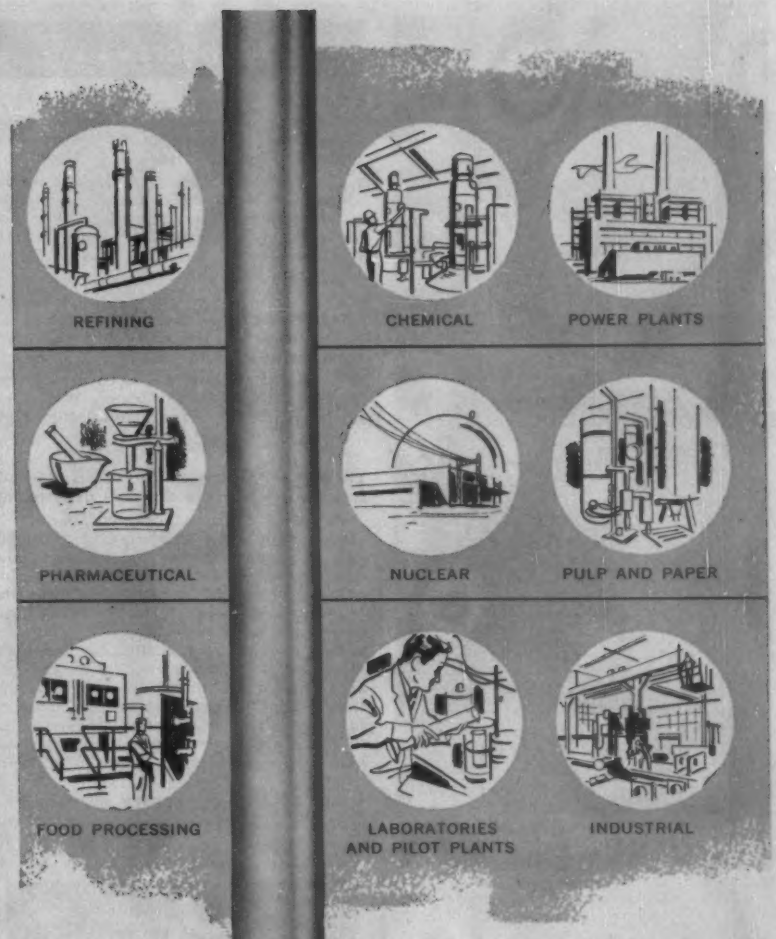
AMERICAN CYANAMID CO. has announced that vice presidents **Kenneth H. Klipstein** and **George R. Martin** have been elected to the newly created office of executive vice president of the company.

Klipstein, who joined Cyanamid in 1933, became a vice president and director in 1957. He has served as assistant general manager of the former Calco division and as general manager of the Research division. In 1951 and 1952, he served as director of the Chemical division and as assistant administrator of the Chemical, Rubber and Forest Products Bureaus of the National Production Authority. Klipstein received a B. A. degree in economics and an M. A. degree in chemistry from Princeton University.

Martin joined American Cyanamid in 1927 to organize a legal department, and served as its head until 1951. He has been a member of the board of directors since 1928, and a vice president for 13 years. He received his B. A. and L. L. B. degrees from the University of Virginia.

INTERNATIONAL NICKEL CO.'s research laboratory at Bayonne, N. J., has named **Dr. Joseph V. Petrocelli** head of the electrochemical section. Formerly director of research and development for The Patent Button Co., Petrocelli joined the Bayonne laboratory staff on August 1, 1957, as a research electrochemist.

As head of the International Nickel Electrochemical section of the research laboratory, Dr. Petrocelli directs activities in improvement of existing processes of nickel plating and plating of nickel alloys, the development of new plating processes, study of the mechanism of corrosion of electrodeposits, study of the microstructure of electrodeposits, and development of new



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In use wherever top performance is demanded. Swagelok Tube Fittings provide a leakproof, torque-free seal. Your Swagelok Specialist will welcome the opportunity to work with you on your particular fitting requirements. For information, write Dept. D2

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Suppliers . . .

engineering applications for chemically reduced and electrodeposited coatings of nickel and nickel alloys.

Dr. Petrocelli holds B. A. and M. A. degrees from Wesleyan University, where he majored in chemistry. In graduate school, he majored in physical chemistry and received a Ph. D. degree in physical metallurgy from Yale University.

ORBIT VALVE CO., Tulsa, has announced the appointment of Arthur J. Burk as representative in Wichita Falls.

David M. Alkire has been transferred from Wichita Falls to Casper, Wyo., and **Owen H. Walker** from Houston to New Orleans.

ETHYL CORP. has promoted **W. K. McCulloch** to a position in the sales department.

McCulloch has been named assistant to the vice president in charge of sales. He will be responsible for the planning and development of future sales programs for existing as well as potential new products. His duties will also be to coordinate this long-range sales planning with other departments of the company. He has been associated with Ethyl since 1932, and has been engaged in the sales, advertising and sales promotion activities of the company throughout his entire career. He served in the Sales department for 16 years, and was named sales promotion manager in 1948.

JONES & LAUGHLIN SUPPLY DIVISION has named **B. E. Irby** local store manager of the store at Longview, Texas, according to **A. G. Bastian,** manager—Field Sales division, Tulsa.

Irby, previously manager of the Gladewater store, joined J&L in 1954. He was appointed manager at Gladewater in July of 1956. Irby served in the U. S. Navy from 1944 to 1946.

TUBE TURNS PLASTICS, INC. has promoted **Donald A. Drake** to Southwestern district manager it was announced by **Carl B. McLaughlin,** executive vice president, in Louisville, Ky.

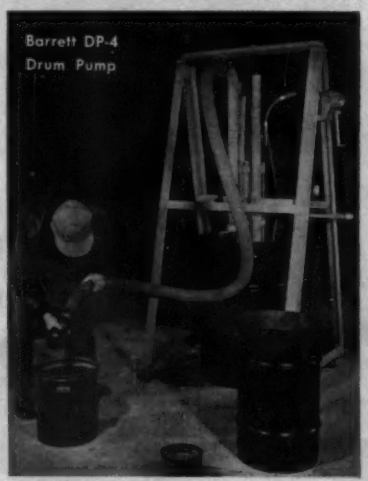
Drake is a native of Louisville. Following military service he attended the University of Louisville and was employed by the Whayne Supply Co. before joining Tube Turns Plastics in 1956, where he became manager of sales services.

GARDNER-DENVER CO. broke ground recently for its second plant in Denver. Officiating at the ceremony were **B. C. Essig,** a member of the board of directors, and **C. H. Rieman,** vice-president and manager of the Denver division.

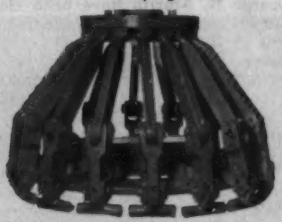
Work has started on the construction of approximately 46,000 square feet of factory buildings to accommodate company equipment.

ALCO PRODUCTS, INC. has announced the organization of a procurement and materials service division. Appointed as director of the new operation is **E. J. Van Valkenburgh,** who will report to **Perry T. Egbert,** ALCO president.

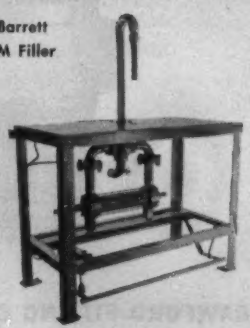
Van Valkenburgh had been manager of procurement and material control for the company. He is a veteran of 37 years service. He joined ALCO in 1921 as an invoice clerk at Schenectady. He is a former purchasing agent for ALCO's Canadian affiliate, the Montreal Locomotive



Barrett Crimping Head



Barrett LM Filler



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for greases and other viscous products

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This huge B&W draw bench for the production of Hollow Forgings is capable of taking a 26,000 pound pierced ingot.

B&W Hollow Forgings —for piping economy in heavy-duty service

Petroleum and power engineers have found a solution of their piping problems at B&W. They save time and money by specifying high-quality B&W Hollow Forgings that have been produced under carefully controlled conditions from initial electric furnace melting through final inspection. B&W production techniques include uniform and thorough working of the ingot, which result in excellent forging properties.

Piping is being supplied in a wide range of fractional sizes and a selected range of standard pipe sizes in carbon, intermediate Croloy and stainless Croloy steels.

For additional information, write for Bulletin S-16. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.

S-474-HP

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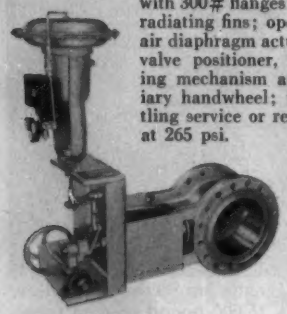
Standard heavy duty butterfly valve with Limitorque electric motor, declutching mechanism and handwheel for air, gases, water or other fluids.



Heavy duty butterfly valve with 300# flanges and heat-radiating fins; operated by air diaphragm actuator and valve positioner, declutching mechanism and auxiliary handwheel; for throttling service or recycle gas at 265 psi.

Heavy duty, wafer-type butterfly valve with worm gear and handwheel for high pressure and for high temperature service in pipe line flow control and shut-off of petroleum, gas or water.

Rockwell valves for petroleum production, refining and pipe line service are designed in many types with manual or automatic control operators, in required metals, body linings and pipe sizes. Write for catalog.

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Suppliers . . .

Works, Ltd., and also has served as a buyer in ALCO's New York office, and as assistant purchasing agent at Schenectady.

AMERICAN CYANAMID CO. has named **Ben F. Melucci** manager of the Industrial Chemicals division, it was announced recently by **G. W. Russell**, division manager.

Formerly technical director of the division's manufacturers chemicals department, Melucci joined Cyanamid in 1946 and has served in a variety of sales development and technical positions in the division. He has also been chemical engineer at the company's Stamford Laboratories and was in charge of the acrylonitrile pilot plant operation.

An engineering graduate of Columbia University, he is a Navy veteran.

Johnson

Havekotte

COOPER-BESSEMER CORP. has announced the promotions of **Roy W. P. Johnson** and **Curt J. Havekotte** to the respective positions of assistant New York district manager and New York branch manager.

Johnson will assist **C. M. Reagle**, New York district manager, in the development of broader sales markets for the company's products throughout the New York territory. Havekotte assumes the supervision of the domestic New York office staff and sales force.

A graduate of Kingston-on-Thames Technical College, Johnson has been with The Cooper-Bessemer Corp. since 1950 and has been with the New York territory since 1951.

Havekotte graduated from the University of Pittsburgh in 1938 with a B.S. degree in mechanical engineering. With the exception of four years of military service, he has been with Cooper-Bessemer in assignments at the main office and in the New York territory.

GENERAL ELECTRIC CO. has announced the appointment of **Harry M. Lawson** as manager—Marketing, the Medium Steam Turbine, Generator and Gear department. **A. T. Chandonnet**, the department's general manager, made the announcement.

In his new position, Lawson will be responsible for all phases of marketing the Department's products.

A native of Baltimore, Lawson holds a B.S. degree in engineering and an M.S. degree in mechanical engineering from Johns Hopkins University.

After graduating from college in 1939, he joined the Baltimore Gas & Electric Co., and remained there until December, 1940 when he entered the U. S. Army. Upon his discharge in 1946 from the Army Ordnance Corps with the rank of major, Lawson joined General Electric in Lynn as a turbine engineer.

GENERAL ELECTRIC CO. has made three district appointments in its Metallurgical Products department.

Harry Jason, formerly manager of tool sales in Detroit and district manager of the New England and Midwestern districts, has been made manager of the newly-organized Southern district.

Succeeding Jason is **John J. Galvin**, who was sales representative for the Atlantic district. A graduate of Lehigh University, where he received a B.B.A. degree, Galvin joined General Electric in 1950 as a trainee in the marketing program. He has held positions as service engineer in the Atlantic district and as sales representative in Indianapolis.

Galvin's former duties will be assumed by **Robert Rennie**, who will be sales representative of the Atlantic district. Rennie is a graduate of DePaw University with a degree in economics. He received his M.B.A. degree at the University of Michigan. He formerly was a sales engineer with General Electric's welding department.

THE INTERNATIONAL NICKEL CO., INC., has promoted John F. Mason, Jr., to Development Activities manager in the petroleum industry for the company's Development and Research division.

Mason succeeds **B. B. Morton**, who will work full time as supervisor of Far Eastern and Latin American developments.

Mason joined the Development and Research division in 1937. Since then he has been with the Corrosion Engineering section. Prior to his association with Inco, Mason was an instructor in chemistry at LaSalle Academy in New York City.

He received his B.A. degree from Manhattan College and did graduate work in chemical engineering at Brooklyn Polytechnic Institute.

AMERICAN CYANAMID CO. has placed Robert A. Olson in the sales office of the Pigments division. He will be responsible for pigment sales of the company in eastern Pennsylvania, Delaware and Virginia.

Formerly with the Pigments division sales office in Los Angeles, Olson has served with several other companies in the paint and varnish industry during the past eight years. He was chief chemist for the Mathews Paint Co. of Los Angeles for three years prior to joining Cyanamid.

Luther E. Beiswanger has been named director of industrial engineering for the company's Organic Chemicals division.

Beiswanger has been with Cyanamid since his graduation in 1940 from the University of Minnesota. He has served the company in various technical and managerial posts since that time.

DRESSER A. G., European affiliate of **Dresser Industries, Inc.**, has expanded its SIE (Southwestern Industrial Electronics) division.

Chris Ring, formerly with SIE of Houston has been appointed manager of the division. **William N. Reese**, also formerly with the Houston company, has been placed in charge of technical services.

JONES & LAUGHLIN SUPPLY DIVISION has announced the retirement of Frank J. Kopp, general salesman, Dallas district.

Kopp who has 40 years and five months of continuous service with J&L, began his career at Augusta, Kan. as a storeman in 1917. In 1919 he moved to El Dorado, Kan. in the same capacity. Kopp became district sales manager at Fort Worth in 1940 and was promoted to manager, Dallas and Fort Worth district in 1941. In 1954

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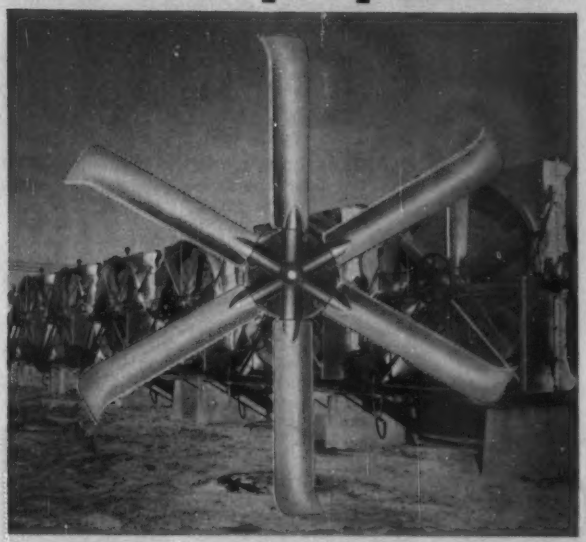

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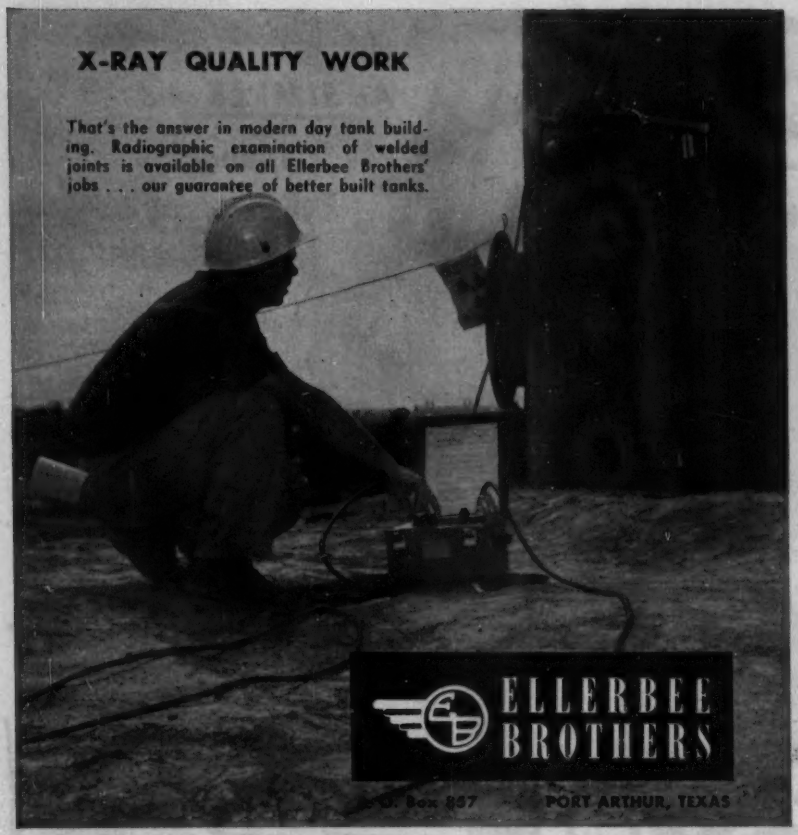
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Suppliers . . .

ill health forced him to relinquish his duties there and he was appointed general salesman for the Dallas district.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has named N. S. Bassett sales manager of the Davies Laboratories division.

Bassett joined Honeywell in 1947 as a field sales engineer of the Boston office. A native of Marblehead, Mass., he graduated in 1941 from Northeastern University, Boston, with a B.S. degree in mechanical engineering.

THE BABCOCK & WILCOX CO. has appointed Neil Robertson acting general traffic manager, manufacturing department, of the company's Boiler division.

Robertson, who had formerly been assistant general traffic manager, will maintain his headquarters at the division's largest plant in Barberton.

THE FOXBORO CO. has appointed **E. R. Huckman** assistant field sales manager of the company, according to **H. O. Ehrisman**, sales manager. With field sales manager **J. J. Burnett**, Huckman will coordinate sales engineering activities of field personnel serving instrument users in the Northern and Eastern sales regions.

Huckman

Although Huckman will continue as regional manager of the New York area, including sections of Connecticut and New Jersey, his duties as manager of the New York City branch have been assumed by **H. R. Cushman**, formerly sales engineer at New York.

Huckman, a graduate of Massachusetts Institute of Technology with a B.S. degree in chemical engineering, joined Foxboro in 1927, working in the Instrument Service and Repair department before assignment to the Tulsa office as sales engineer. In 1931 he moved to the St. Louis office and ten years later to New York where he served as assistant manager and later, manager.

KOPPERS CO., INC., has formed two new divisions to replace the company's former Chemical division.

David L. Eynon, Jr., president of the Mobay Chemical Co. for the last four years, has resigned that position and on April 1 will become vice president and general manager of the Plastics division, newly formed by Koppers. At the same time **T. C. Keeling, Jr.,** has been named vice president and general manager of a newly formed Chemicals and Dyestuffs division of Koppers.

Eynon received a B.A. degree in 1931 from Williams College. He then attended the Massachusetts Institute of Technology from which he received a M.S. degree in chemical engineering in 1933.

After graduation he joined Monsanto Chemical Corp. in its research department at Everett, Mass. Since then he has been superintendent of the acid department, plant manager of the Longhorn Ordnance Works at Marshall, Texas, operated by Monsanto, and assistant general manager

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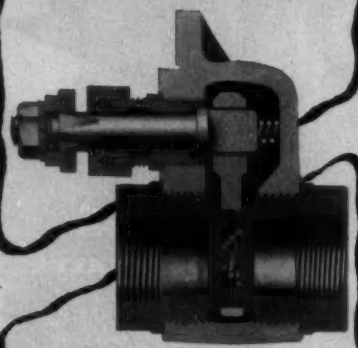

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Suppliers . . .

of Monsanto's Organic Chemical division at St. Louis. In 1954 he was named president and director of Mobay Chemical Co.

Keeling, who has been assistant vice president in the Chemical division of Koppers, joined the company in 1945 and became sales manager of the division in 1946. During 1952 and early 1953 he was director of the Chemical division, National Production Authority at Washington. He returned to Koppers but in 1953 joined Mathieson Chemical Corp. as head of their Hydrocarbons division. He again returned to Koppers in 1954 and has been manager of American Aniline Products, a unit of Koppers Co.

THE GARLOCK PACKING CO. has named William K. Chestnut product manager of the company's Leather Packing division, Philadelphia.

Chestnut has been associated with the Garlock organization since 1934, first with the Philadelphia branch sales office, and since 1938, with Mechanical Leathers.

CAPITOL PRODUCTS CORP. has named George H. Stram chief engineer of the chemical equipment of Read Standard division.

Stram most recently headed his own engineering organization. Prior to that he was chief engineer of the Sprayer department for the York division of Oliver Corp.

He has served on a variety of industrial and governmental committees on construction and development of agricultural and chemical equipment, including the chairmanship of the Equipment Sub-committee of the American Road Builders Assn. on Roadside Construction and Development. He was also chairman of the governmental Committee on Pesticide and Application Equipment.

SPARTON CORP. has named Robert C. Ayres, Jr., of Houston regional sales representative for Flori-Houston, the company's pipe fabricating divisions, comprising the Flori Pipe Co. and Houston Pipe and Steel, Inc., of Houston. His territory will comprise the Gulf Coast area, Texas, southern Arkansas and Louisiana, including accounts in Houston.

Ayres has had 12 years sales experience with mechanical and industrial firms in the Gulf area, and about four years experience in small plant management. He studied mechanical engineering at Texas A & M College.

ROCKWELL MANUFACTURING CO. has named Phillip W. Goodwin, Jr., general manager of its Sulphur Springs, Texas, valve plant for the past five years, general manager of the company's new 180,000-square-foot valve plant at Kearney, Neb.

Goodwin joined Rockwell in 1944 as purchasing agent of Rockwell's Oakland, Calif., valve plant.

In 1952 he was put in charge of Rockwell valve parts production at several outside manufacturing facilities in the Oakland area. He was named general manager of the 120,000-square-foot Sulphur Springs plant in May, 1953, while it was still under construction.

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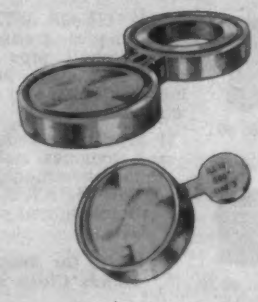

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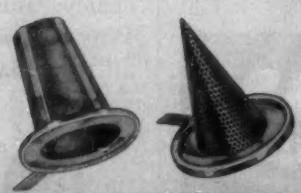

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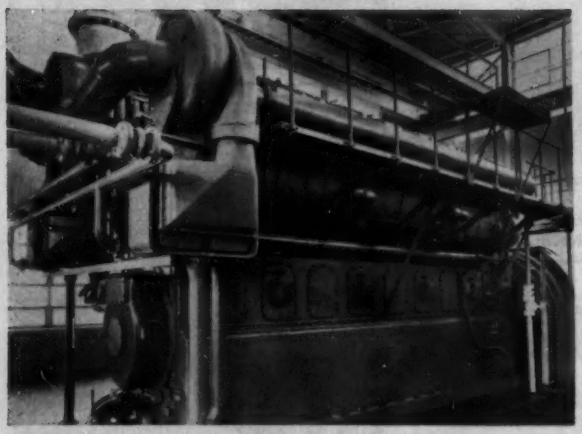

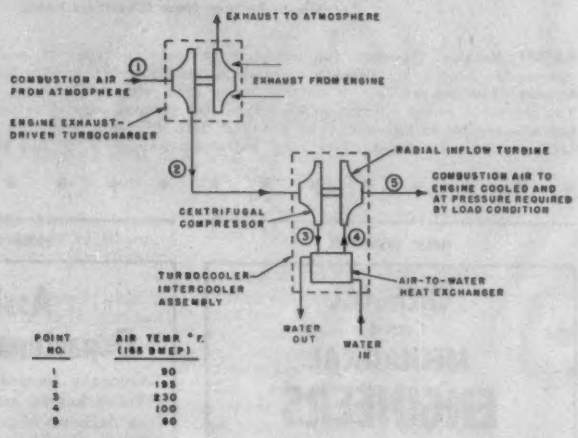

Cool Combustion Air Ups Engine Power

Turbocooling, a method for supercooling combustion air, provides an important potential for increasing horsepower output of gas or gas-diesel engines. In some cases these increases are as much as 23 percent. At the same time, reductions as high as 5.0 percent in fuel consumption are being realized, according to actual field experience.

Basically, the turbocooler is a turbine-driven centrifugal compressor equipped with an aftercooler. In the past, air from the engine turbocharger has been throttled to the air manifold to maintain correct air-to-fuel ratio. The conventional practice has been to do this with the butterfly valves. Experience has shown this practice a simple waste of energy with little, if any, effect on cooling the intake air. The introduction of the turbocooler, however, has created a practical method of utilizing an abundant source of energy created by a pressure drop in the manifold, which would further cool the combustion air going to the engine cylinders.

The cooling cycle of the new development is shown in the diagram. In this system, filtered air enters the high pressure turbocharger (1) and is compressed by the exhaust gas driven centrifugal blower (2). The pressurized air at elevated temperature from compression is then directed to a booster (3) in the turbocooler for a second stage of compression. As the air leaves the booster, its temperature and pressure are considerably higher than after the first stage of compression. This air is then cooled by an air-to-water intercooler (4) before entering a turbo-expander (5).

Since the pressure of the air entering the turbo-expander (5) is greater than the air intake requirements of the engine, a pressure drop is available through the expander to motivate the expander impeller causing the impeller to spin. As the same air expands through the impeller, its temperature is reduced by 15 to 40 degrees.

The net effect of the turbocooler is to provide the engine with cool combustion air. The more air or oxygen that can be concentrated in the cylinders, the more efficient the combustion of the fuel and the more fuel the engine can take. As a result, engines equipped with turbocooling have the advantage of higher overload capacity with less danger of detonation and less BTU consumption per brake horsepower hour.

The photograph shows a supercharged, spark-ignited gas engine equipped with Turbocooler. The engine is rated at 4380 horsepower. The Cooper-Bessemer Corp.

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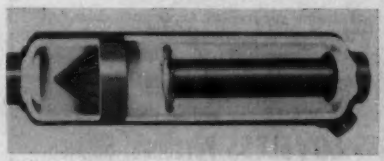

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A new helicoid tuyere combined with a secondary vortex breaker now is increasing the separating efficiency and widening the range of flow of the new Type RA Line Purifiers. This results in more complete removal of water, oil, pipe scale, rust and sediment from compressed air, steam or vapor lines.

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As vapor enters the purifier, the helicoid tuyere directs it into a whirling mass that forces all entrainment to the inside wall of the purifier body. At the same time, the design of the tuyere also controls the primary vortex action. The heavier particles flow down the inside wall of the purifier to the drain pocket where they are removed while the clean, dry gas or vapor passes through the purifier outlet. The vortex breaker at the beginning of this outlet further prevents any re-entrainment due to secondary vortex action. Centrifix Corp.

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Epoxy-Glass Pipe—Strong As Steel But Lighter

Corrosion-resistant reinforced plastic pipe, strong as steel but only one-eighth the weight, is now being manufactured in 2 to 12-inch diameters to meet ducting, tubing and piping needs of the process industries. The manufacturer uses a patented process employing interwoven fiber glass filaments, impregnated with epoxy resins and heat cured.

The new pipe comes in rigid 20-foot lengths with ends plain, bell-and-spigot or flanged. Other lengths, as well as diameters up to 40 inches, are available on special order.

The pipe is nontoxic, nonflammable and crush-resistant, and does not cold flow or sag in use. It may be used for water, salt solutions, petroleum hydrocarbons and solvents, and most dilute acids and alkalis. Its smooth, friction-free interior surface resists scale and paraffin deposits, assuring full rate of flow for the life of the pipe.

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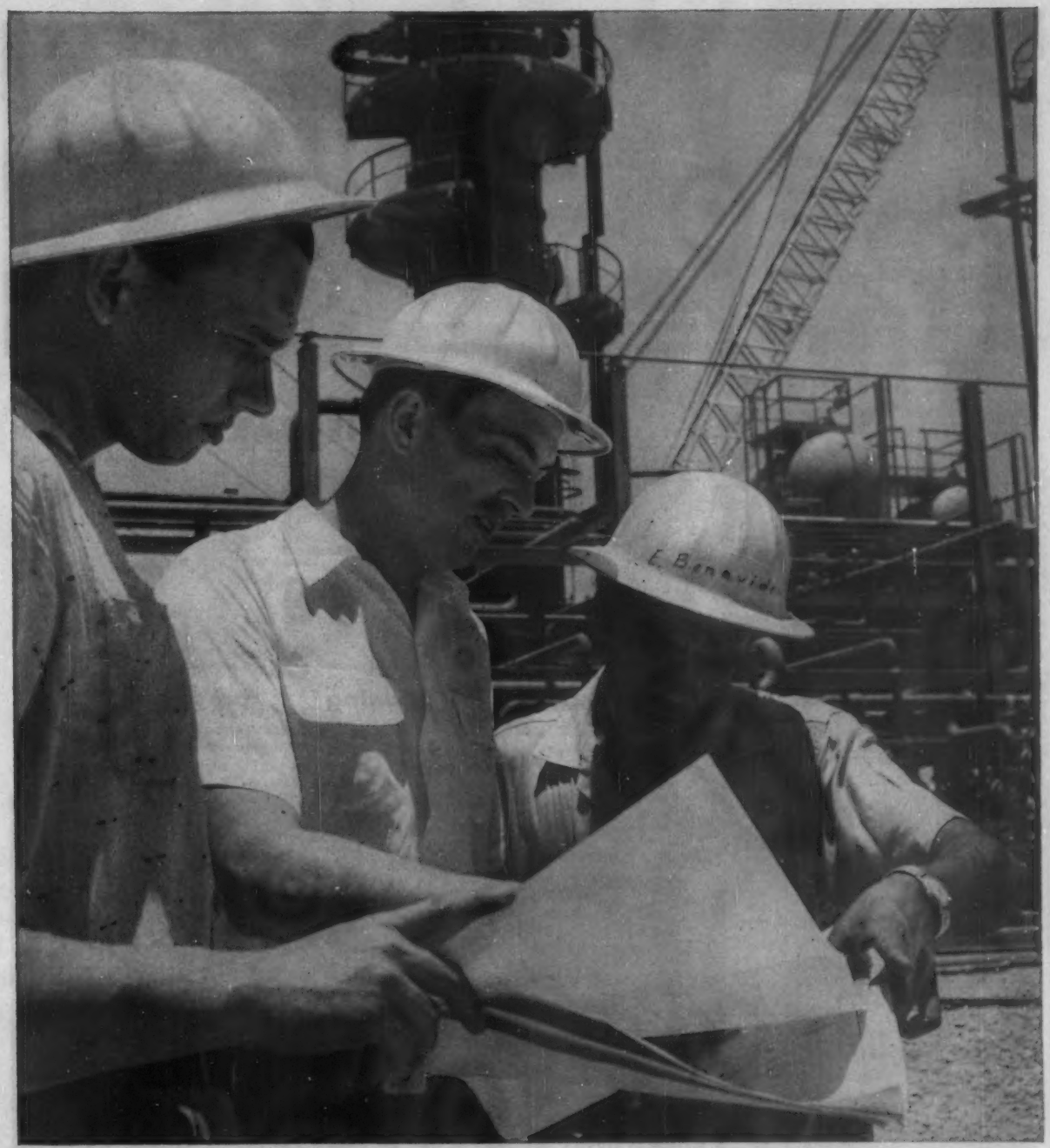

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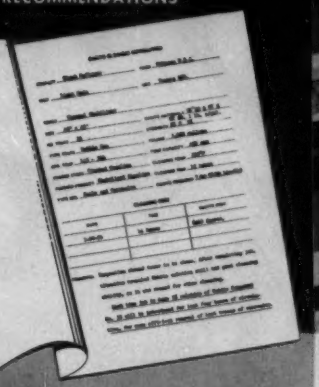

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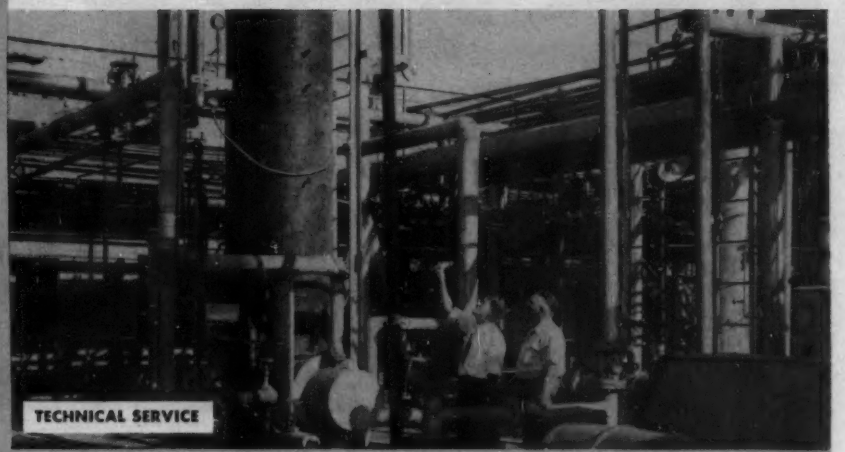

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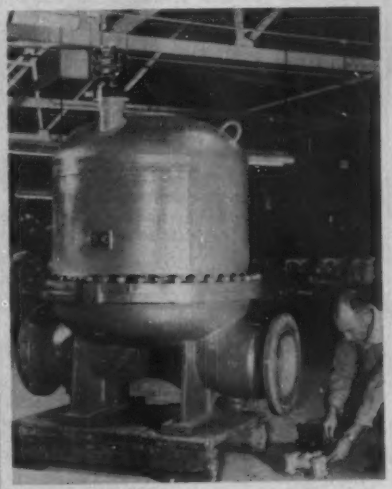
psi and another rated at 500 psi. Greater pressure ratings may be attained on special order since the manufacturing process permits "beefing up" wall thickness as required.

Tensile strength of the pipe is 80,000 psi circumferential and 40,000 longitudinal. Specific gravity of the fiber glass and epoxy material is one fourth that of steel. Wall thickness, however, is only about half that of steel pipe, so that finished Bondstrand pipe weighs one-eighth of its steel counterpart. Amercoat Corp.

Circle E3 green card, last page



Positive Displacement Meter Handles 5000 bhp

With capacities to 5000 barrels per hour at working pressure of 300 psi, the new positive displacement model B-123 meter is designed to handle petroleum products or crudes in pipelines, bunkering, barge and tanker loading, refinery runs to stills, and other high capacity services (See photo-small one and one-fourth inch at right illustrates the range of Brodie's meter capacities).

Double case construction isolating the measuring unit from piping strain, antifriction stainless steel ball bearing rotor mounting, balanced true rotary operation without vanes or reciprocating parts, absence of metal-to-metal contact with just two moving parts in the measuring chamber are said to contribute to sustained accuracy and minimum maintenance.

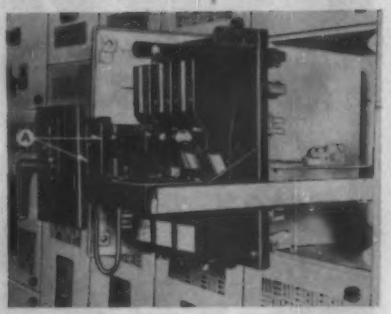
Removal of cover dome provides complete accessibility to the measuring unit for inspection, cleaning or replacement, without disturbing line connections. The meter is available with 10 inch or 12 inch 150 pound or 300 pound ASA flanges, or weld ends for welding directly into pipeline.

The outer housing consists of welded cast steel base and formed steel cover dome. Timing gears and worm gear counter drive are fully enclosed from flowing stream. Dry adjustment in increments of .05 percent may be made while meter is in operation.

The B-123 meter is available with a choice of counters, printers, remote counter system, or accumulator system to permit use of two or more meters of equal or varying sizes operated in parallel. It may also be provided with an automatic temperature compensator to give counter readings in net barrels. Ralph N. Brodie Co.

Circle E4 green card, last page

New Equipment . . .



Three-Position Breaker Design In New Switchgear

A new (Type DB) 600-volt, 15 to 4,000 amperes, metal-enclosed switchgear with three-position breaker design is now available. The interrupting rating of the units are from 15,000 to 100,000 amperes.

With the circuit breaker in any of its three recognized positions—connected, test and disconnected—the door of the breaker compartment can be closed. Indication of the breaker position is provided by two white lines on the mechanism. When both lines show, the breaker is in the disconnected position with both primary and secondary contracts disconnected. When one line is visible, the breaker is in the test position with primary contacts separated but the secondary contacts engaged for test purposes. When neither line shows and the small faceplate is flush with the switchgear door, the breaker is in the connected

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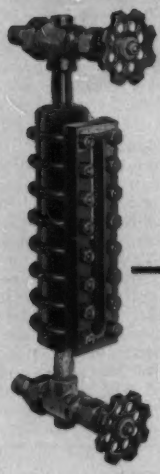
For more data on advertised products, use Readers' Service Cards, last page.

Get the LEVEL READINGS of LIQUIDS THAT BOIL and Flash



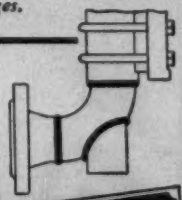
Jerguson Large Chamber Gage

The Jerguson Large Chamber Gage is designed to indicate the level of liquids whose tendency to boil and flash makes an accurate level reading impossible with ordinary gages.

The chamber of this Jerguson Gage is of such large diameter that the level is not badly upset by boiling action of the fluid. This makes possible close level readings, the kind you want and need for accurate control and safety.

You don't have to be satisfied with gages that require guessing at level readings. If liquids boil, install Jerguson Large Chamber Gages and be sure of the liquid level.

The Jerguson Large Chamber Gage is available in reflex and transparent types. Write for full information on this and other Jerguson Gages.



Tapped ¾" pipe threads standard. Available with 2" flanged ends for direct connection to vessel.

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New Equipment . . .

position with all disconnecting contacts engaged.

The three position feature offers additional convenience and safety to operating and maintenance personnel, and greater protection for the circuit breaker. Other advantages include: (1) free aisle space regardless of breaker position; (2) disconnected breakers while maintaining equipment controlled; and (3) easy recognition of breaker position. Westinghouse Electric Corp.

Circle E5 green card, last page

Thermocouple Accessories In Complete Buyers' Guide

Catalog G100-8 describes the company's complete line of thermocouple accessories for measuring temperature. This issue includes new assemblies and new insulated extension wire. Minneapolis-Honeywell Regulator Co.

Circle E6 green card, last page

Thermal Element Guide For Corrosive Atmospheres

Selection of thermal elements for maximum resistance to corrosive atmospheres is made easy with a new folder recently published. The folder, "Thermal Element Selection Guide for Corrosive Atmospheres," lists more than 400 separate corrosive atmospheres into which temperature control elements are often immersed. In easy-to-read chart form the company lists the recommended bulb material and other information relating to sustaining the life of temperature sensing bulbs in each atmosphere. The Partlow Corp.

Circle E7 green card, last page

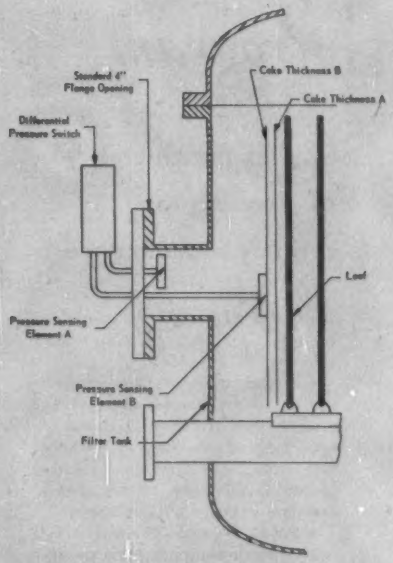
Portable Ultrasonic Unit Measures Metal Thickness

A completely portable, battery-operated ultrasonic thickness measuring unit has recently ben perfected. It locates areas of corrosion or wear on storage tanks, pipes and other structures and products accessible from one side only.

With an entirely new means for reading ultrasonic thickness measure, it is fast, positive, and simple to operate. In effect, it gives direct readings of thickness. The operator selects the proper crystal range, places the probe on the test area, and rotates the circular read-out dial until the harmonic lines match a pattern of flashing lights. He then reads thickness directly from the dial.

The SO-200 requires no warm-up time. It measures with an accuracy of ± 3 percent on thicknesses between .027-inch and 4 inches, and works on practically all materials which will transmit ultrasonic sound. Magnaflux Corp.

Circle E8 green card, last page



Automatic Filtration With Cake Thickness Detector

For the first time, the accurate control of cake thickness is a principal factor in the complete control of the filtration cycle. When the cake reaches its predetermined maximum allowable thickness, the Durco-Enzinger Cake Thickness Detector triggers the next step in the filtration cycle, or sounds an alarm to warn the operator of a manually controlled unit.

The detector, combined with standard control instruments for the other process variables, flow, pressure, and clarity, makes possible the complete automation of Enzinger filters. The unit becomes immediately sensitive to all the operating variables, and eliminates the need for direct operator control.

Normally, leaf pressure filters are sized

use these READERS' SERVICE CARDS* for more information

* see inside back cover

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MULTIPAIR CABLE

it cuts installation costs

When four or more pairs of thermocouple extension wires are needed, SERV-RITE thermocouple extension cable will reduce installation costs several ways. It takes considerably less time compared to pulling individual pairs of wires through conduit. Cable also permits the use of much smaller conduit than for the same number of individual wires. It can be hung without conduit, or installed in open trough or by direct burial.

The cable, as well as each conductor, is color coded. Also, each pair of wire is marked for quick identification.

Cables with multiple pairs of four or more conductors of the commonly used types are carried in stock.

Write for Bulletin No. 1200-3
for specifications and data on SERV-RITE thermocouple extension cables.

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New Equipment . . .

with a large safety factor which permits the filter to hold unexpected surges of solids without damaging the leaves. However, this safety factor is quite expensive. The new detector, however, provides positive control over the thickness which the cake can attain. This eliminates the threat of bridging and reduces considerably the factor for safety purposes. Thus, filters can be sized much smaller than was heretofore safe. For example, a process that formerly required a 500 sq. ft. filter might be handled completely adequately with a filter half that size utilizing a Cake Thickness Detector.

The company feels that this filter now can compete with continuous rotary vacuum filters on solids that are sufficiently free filtering to deposit a normal leaf cake. Capital investment is considerably less, and performance will equal that of the rotary drum vacuum filter.

The operation of the detector is extremely simple. When the filter cake reaches its predetermined maximum allowable thickness, it covers the face of a pressure-sensing diaphragm mounted on a tube that extends into the filter tank. When the diaphragm becomes slightly embedded in the cake, hydraulic pressure on its face is slightly less than tank pressure. This element actually senses the beginning of a hydraulic pressure drop through the filter cake. Difference between this pressure and that sensed by a similar element exposed to the full tank pressure actuates a differential pressure switch in the control or alarm circuit.

The Durco-Enzinger Cake Thickness Detector has been extensively tested on a wide range of filter cakes, pressures and flows, with conclusive proof that this new device will be an invaluable aid to the filtration and automation engineer. The Duriron Company, Inc.

Circle E9 green card, last page

Graphic Burst Discs Accurate to 5 Percent

The immediate availability of a new, high quality graphite burst disc for process pressure vessels has just been announced.

Mounted in a special carbon or aluminum holder, the discs are easily replaceable and are accurate to plus or minus 5

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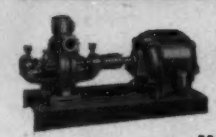

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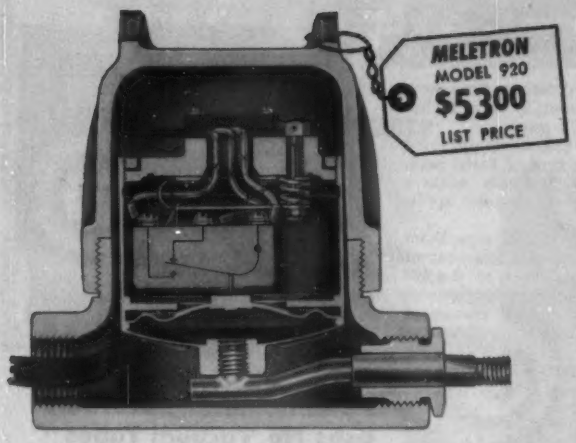

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IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	**ACCORDION DIAPHRAGMS** which make the pressure switch sensitive to vibration.

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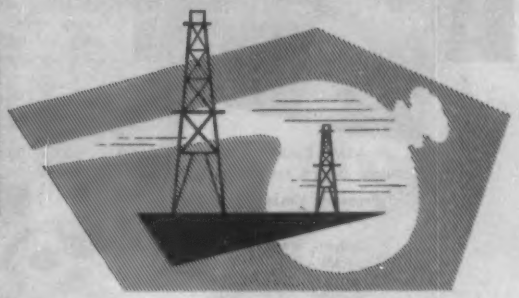

An outstanding development in British industry in the last twenty years has been the expansion of the Petroleum refining and Chemical Industries. The Chemical and Petroleum Engineering Exhibition—the first of its kind—will present dramatic evidence of the tremendous achievements that have been made.

At Stand after Stand, contractors, designers and specialists in every branch of British chemical and petroleum engineering will have something to show of vital interest.

The Exhibition will also include a conference on "The Organisation of Chemical Engineering Projects" arranged by The Institution of Chemical Engineers and The Institute of Petroleum; and films will show how the Chemical Plant and Petroleum Equipment Industries have helped in the development of their consumer industries.

A visit to this Exhibition is a MUST to all concerned in chemical and petroleum projects and to everyone whose industry is in any way influenced by such projects.

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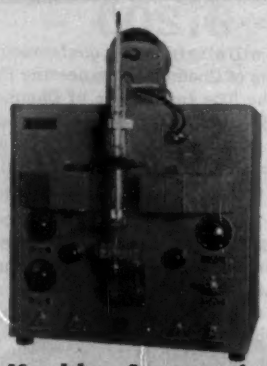

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New Equipment . . .

percent of rated burst pressure. Sizes now in production range from 2 to 6 inches with ratings from 5 to 75 psig.

Operating pressures can be maintained indefinitely up to 75 percent of rated pressure, and the unit is available with a graphite support bar for vacuum applications.

The chief advantages of the new burst disc are its accuracy and the low cost of replacing the discs. Economies to the refining and petrochemical industries, as well as others, are substantial compared with existing devices. Delanium Graphite Co.

Circle E10 green card, last page

Pressure Switches Operate Through Wide Range

A new line of pressure switches, of special interest to the chemical and processing industries, has been developed by Meletron. Proof pressures range from 224 to 6000 psi, pressure settings from 2 to 4800 psi. Switches will operate in temperatures from —65 F to 275 F. Standard pressure port fitting is one-fourth inch internal pipe thread but may be substituted by special welding fitting. The housing serves as a pressure tight safety capsule in case of a break in the sensing element. Single pole double throw switching elements are rated to 10 amps., for AC and DC circuits. Free leads or Cannon plug are optional for electrical connections. Barksdale Valves.

Circle E11 green card, last page

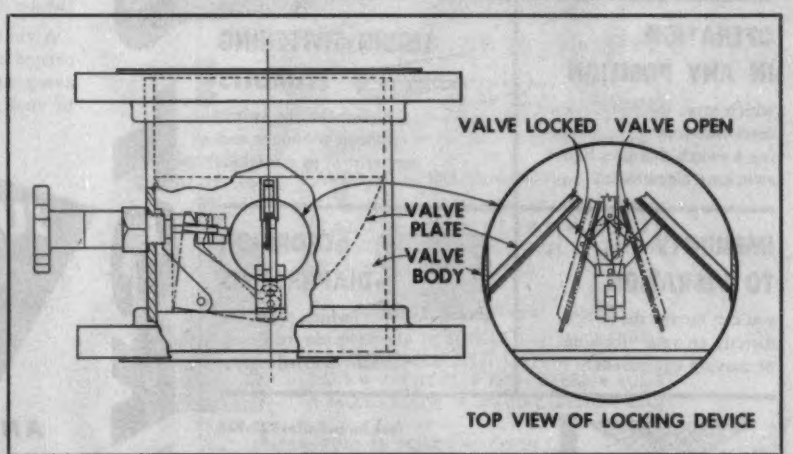
Potentiometer Recorder Uses No Vacuum Tubes

A truly distinctive strip chart potentiometer recorder is now being introduced. Entirely free of vacuum tubes, it operates instantly, without warm-up, and functions far longer without maintenance. This recorder uses printed circuits and transistors in its amplifier.

Several of the features included in this basic thermocouple recorder by West without extra charge are usually available only at premium prices. Automatic standardization, thermocouple break protection, cold junction compensation, chart tear-off strip, adjustable chart speeds without changing gears, battery condition indicator, etc.

This "Marksman" is said to be sensitive and accurate, with full selection of scale ranges and chart speeds. It will record any variable that can be transformed into an electric signal through transducers—strain, pH, temperature, pressure, etc. It operates at 115, 208 or 230 volts and requires no additional transformer. It fits any standard 19-inch relay rack, flush or surface mounted. West Instrument Corp.

Circle E12 green card, last page



Check Valve Has Closed Position Locking Device

Recent modification of the technocheck valve, a patented silent, seatless check valve, provides a device for locking the valve in the closed position.

The new feature affords protection where sticking of the valve in the open position may cause disruption of processes or service.

The device is arranged so as to have no fixed connection with the valve. Locking is accomplished by a cam mechanism

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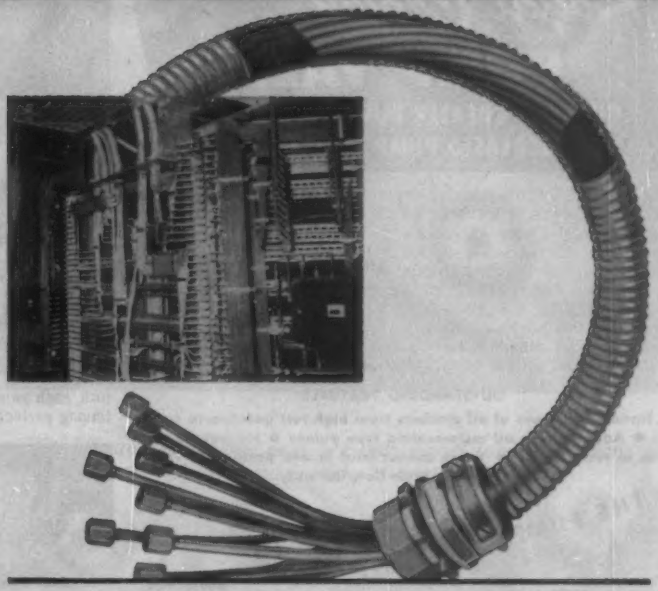
CRESCENT ARMORED MULTITUBE® is a group of tubes spirally cabled together. One tube in each layer is a bright blue color, which makes identification of any tube at both ends an easy matter.

Users report savings in installed cost of from two to five times the cost of CRESCENT ARMORED MULTITUBE as compared with the old method of using single tubes. Using the MULTITUBE system will result in fewer connections and fittings, lower cost for supports or racks, ease of mounting and less space.

The spiral cabling of the tubes prevents distortion when the entire assembly is bent on a short radius. The tubing assembly is protected by a flexible, interlocked galvanized steel armor, or by a tough corrosion-resistant thermoplastic sheath or both.

Furnished in from 2 to 37 Tubes of copper, aluminum, steel, polyethylene up to 1000 feet. Also special construction for underground runs. This product is licensed under U. S. Patent 2,578,280.



Instrument panel shows 21 runs of CRESCENT ARMORED MULTITUBE.

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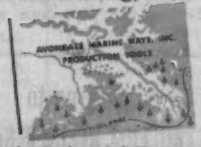

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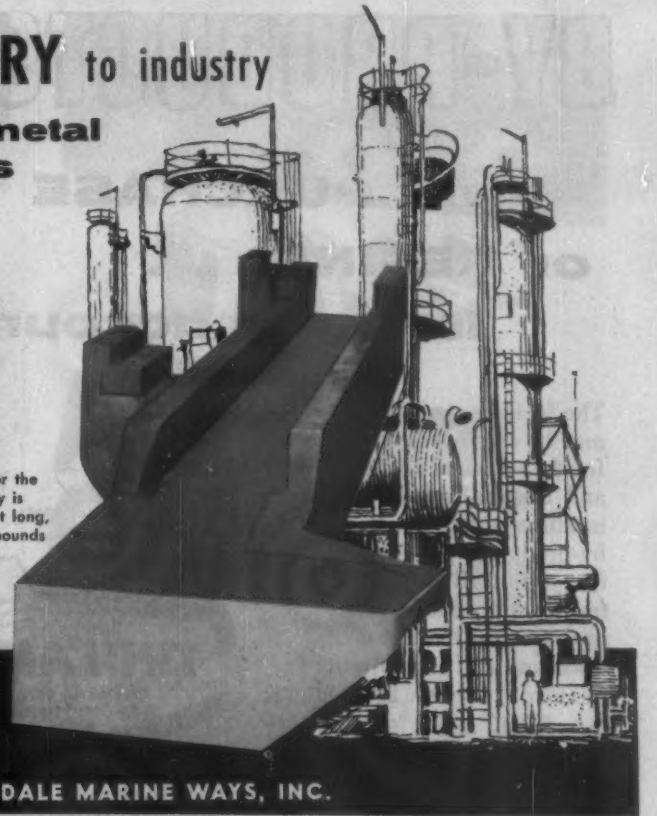

This large casting for the Petroleum Industry is approximately 16 feet long, weighs about 7000 pounds

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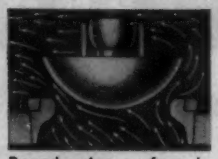
Look at the illustrations at the right and you can see why ROYAL CROWN PUMP VALVES give such outstanding performance. These valves are guided by a frictionless ball stem (not a rigid guide). This allows them to oscillate and turn freely with the fluid stream with a minimum of resistance to the fluid. The result . . . greater pump volume at less pump speed. ROYAL CROWN VALVES swing free, with each stroke of the pump, seating perfectly every time in a new position. This means longer valve life and maximum pump efficiency. Get all the facts today on this revolutionary valve.

OUTSTANDING FEATURES

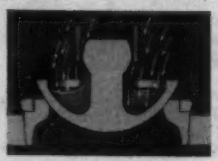
● Handles all types of oil products from high test gasoline to crude oil ● Adaptable to all reciprocating type pumps ● No crossbars in seat to restrict flow ● Valve cannot bind in any position ● Valve releases and seals flow instantly

THE PUMP VALVE WITH 1000 SEATS
EACH TURN . . . EACH SWING — A PERFECT SEAT.



Round valve surface is streamlined. No obstructions to restrict the flow.

Ball-guided valve rotates and swings with each stroke of the pump. Each turn, each swing . . . a continuing perfect seat.



Free vertical action assures instant opening and closing. Ball stem is a frictionless guide.

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New Equipment . . .

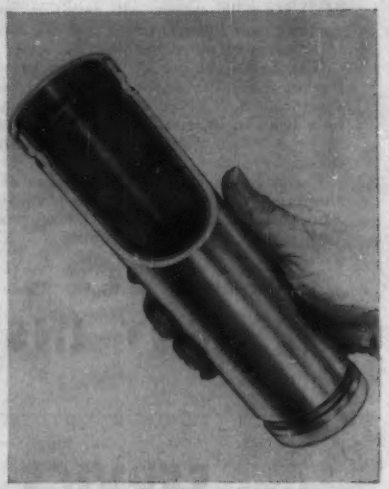
which rotates against valve members to hold them closed.

The mechanism can be activated manually by a hand wheel or mechanically by means of a solenoid valve, cylinder or similar control.

When the valve is locked, it must be opened to resume functioning. The locking device is not intended to hold the valve against upstream pressure but serves to show that the valve is positively closed.

The valve is furnished in various materials and is built in sizes from 4 inches to 14 inches inclusive. Techno Corp.

Circle E13 green card, last page



Corrosion Resistant PVC Pipe Has Steel Jacket

A new type of pipe combining the strength of steel with the chemical resistance of plastic is now being produced.

This product, to be marketed under the name of "Jal-Jacket," consists of a rigid polyvinyl chloride (PVC) tube which is jacketed with an electric resistance welded steel pipe.

Polyvinyl chloride plastic was chosen as the Liner material because of its excellent and widely recognized resistance to a broad range of corrosive fluids. By using a steel jacket, the limitation of pressure common to most plastic pipe is overcome and working pressures of 1,000 psi at 150 F are easily attained. Jal-Jacket is so designed that the pipe-ends as well as the

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POSEY PRESSURE VESSELS

These twin tanks were fabricated by POSEY for propane storage for a South American industry. Each tank is 34′ long and 10′ in diameter. Fabricated from 1″ steel plate, these tanks operate at pressures up to 250 pounds per square inch.

POSEY pressure vessels are in service in most civilized parts of the globe. With almost a half-century of experience, Posey is well equipped to design, fabricate and erect pressure vessels of all types and sizes . . . of steel or alloy steel . . . for liquid or gas.

Posey pressure vessels are tested to considerable excess over normal working pressures. All standard codes are met, including ASME and API-ASME.

Let POSEY quote on your next pressure vessel job. Quotations and other information upon request without any obligation.

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STEEL PLATE DIVISION LANCASTER, PENNA.
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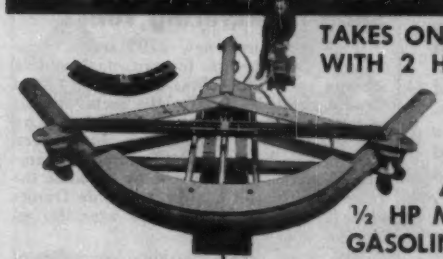
Established 1910

TANKS • STACKS • DIGESTERS • PIPE • PILING

LIGHT PORTABLE TOOL BENDS 8″ PIPE 90°



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ALSO USES ½ HP MOTOR OR GASOLINE MOTOR

- **EASY TO USE**—Quickly set up for pipe size and bend desired. Quick-releasing bending shoes. Bend indicator.
- **EASY TO MOVE**—Swiveling casters. Frame folds back for compact storage. Simple sections are quickly dismantled.
- **FAST and POWERFUL**—Hydraulic cylinder has 4½″ bore and 60″ ram travel. Pump develops up to 10,000 p.s.i.
- **SMALL and LIGHT**—By far the smallest, lightest, most economical bender available in this capacity.

SAVE UP TO 90% on piping jobs! Minimize pipe cutting and welding time . . . save cost of elbows!

You can make perfect, wrinkle-free bends . . . on the job or in the shop . . . with this low-cost hydraulic tool. Bends made cold, in just one setting. No filling.

Interchangeable parts handle ⅜″ to 8″ pipe, X or XX. 8″ XX pipe bent 90° in only 3 min. when using 2 hp. motor. Also operates with ½ hp. motor or gasoline engine.

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for ramps, walkways, pit covers, floorings, etc.

Patented Upset design provides sure-footed, non-skid, non-directional safety—even in the presence of wet, greasy or other hazardous conditions. Non-magnetic, non-sparking and maintenance-free! Washington Aluminum will fabricate any shape, width or length grating to answer your most exacting requirements. Free booklet on request.

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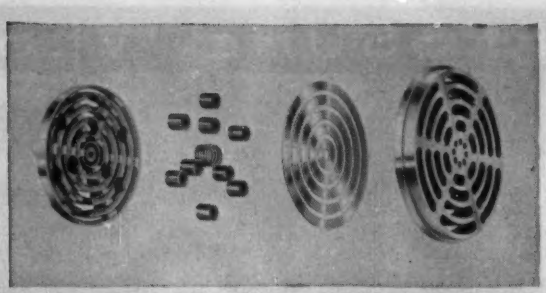

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for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
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VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable ... ductile ... resist fracture, high temperatures and corrosion ... withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

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a single, central instrument instantly reads temperatures at up to 23 locations

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HIGH RESISTANCE INDICATING PYROMETERS

Pilot plants, laboratories, power plants, ships and industrial processors are using this efficient and economical method. A Veri-Tell pyrometer, selector switch and terminal panel (plus thermocouples and leads) comprise the unit. Wide selection of scales and ranges. Where thermocouple leads must be of different lengths, calibrating spools may be added.

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THERMOCOUPLE SWITCHES
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New Equipment . . .

inside surfaces are continuously protected. Positive seal and quick make-up are provided by the use of Victaulic couplings which lock into mill-rolled grooves.

The new steel-jacketed PVC pipe will be available in 20-foot mill lengths in the 2-inch, 3-inch, and 4-inch nominal O.D. sizes. Currently, only the 2inch nominal (two and three-eighth-inch O.D.) size is being offered but the 3-inch and 4-inch sizes will be in production by the second quarter of 1958. Jones & Laughlin Steel Corp.

Circle E14 green card, last page

Flow Meter Features Snap-In Metering Tubes

This company's new 2700 series variable-area flowmeters feature packing-less, snap-in metering tubes. By using O-rings to seal the tube ends to the metal fittings —nuts, bolts, stuffing boxes, packing glands and all adjustments have been eliminated. Piping strains cannot be transmitted to the glass metering tube since the tube "floats" in the O-rings. Side frames and front and rear covers are also of snap-in construction.

The new design permits coverage of flow ranges from a fraction of a cc/min to 40 gal/min with only three meter sizes. Formerly eight sizes were required. Inventory costs can therefore be reduced 50 to 75 percent. Metering tubes can be "snapped-in" without the use of any tools and without disconnecting or disassembling the meter. Cleaning and range changing

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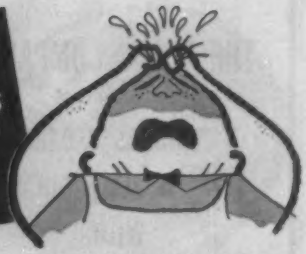
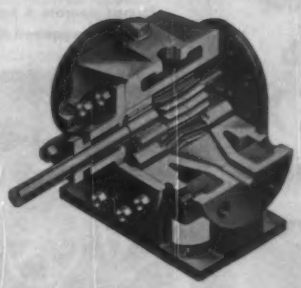
Craftsmen in steel plate and alloys up to 1"

DON'T GIVE UP when viscous liquids cause pumping problems . . .



An SK Steam Jacketed Gear Pump can restore that old equanimity—keep the brass happy and you smiling.



Engineers and production men in many varied industries are using SK Steam Jacketed Herringbone Gear Pumps to handle viscous materials of many types—heavy fuel oils, asphalt, vegetable shortening, glue, and others.

Take a tip from these folks. Send for a copy of Bulletin 17-A which describes SK's line of pumps. Or, acquaint us with your problem. We'll help.

Schutte and Koerting COMPANY

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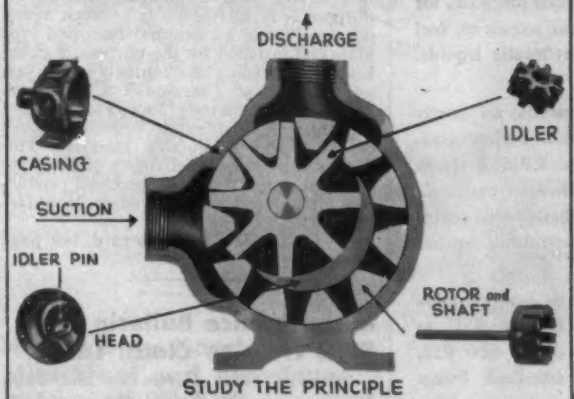
Jet Apparatus: Ask for Condensed Bulletin J-1.	Rotameters & Flow Indicators: Ask for Condensed Bulletin 18-RA.	Valves: Ask for Condensed Bulletin V-1.	Heat Transfer Apparatus: Ask for Condensed Bulletin HT-1.	Gear Pumps: Ask for Bulletin 17-A.

Viking Operating Principle



STUDY THE PRINCIPLE

Above are illustrated the major parts of the Viking Pump—casing, head, rotor and idler, separately and assembled. Imagine the rotor and idler in motion operating in a counterclockwise direction. Follow the course of the liquid from point of suction to point of discharge. Reverse direction will operate equally well. We invite your inquiries.

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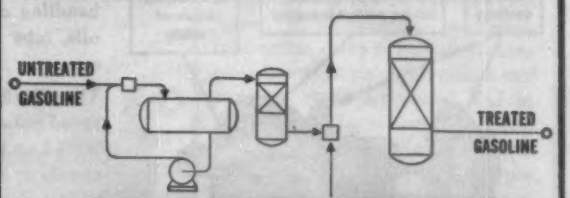

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For more data on advertised products, use Readers' Service Cards, last page.

THE TEXAS COMPANY
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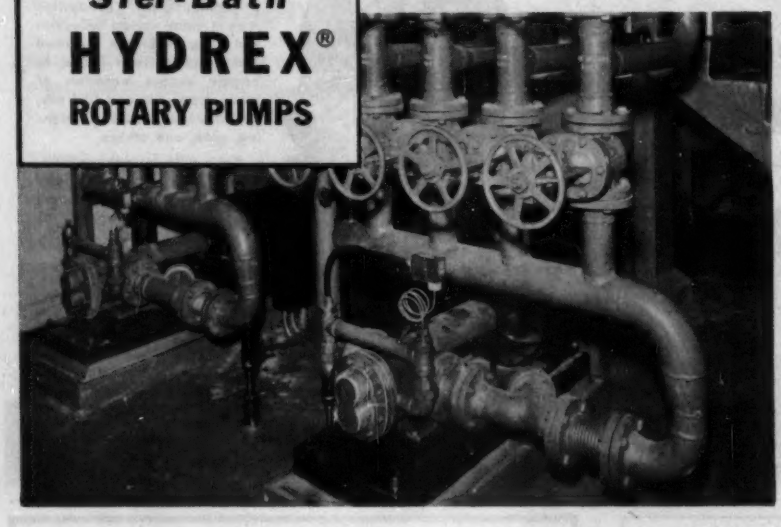
Sier-Bath
HYDREX®
ROTARY PUMPS

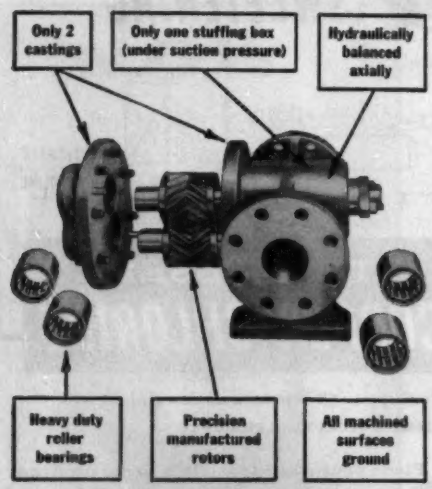
ADVANTAGES THEY GAINED:

- 20" Hg. suction lift
- 25% power savings
- Faster starting
- Greater cleanliness
- No maintenance
- Low-cost pumps

Five Hydrex Rotary Pumps, installed 3 years ago, transfer lube oils from compounding kettles to storage tanks. Rated at 150 gpm., they pump oils with viscosities of 1,200 to 1,400 SSU at 60° to 140° F., with 20" Hg. suction lift at discharge pressures of 90 psig. Starting time is 15 seconds compared with 3 to 4 minutes previously. Pumps operate 4 hours a day, 5 days a week and have required no maintenance.



Sier-Bath HYDREX PUMP

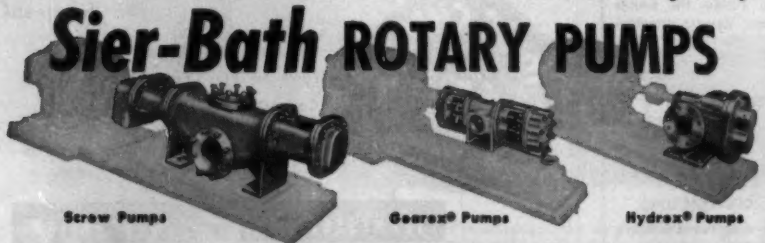

Only 2 castings
Only one stuffing box (under suction pressure)
Hydraulically balanced axially
Heavy duty roller bearings
Precision manufactured rotors
All machined surfaces ground

The simplest heavy duty gear pump made! Use it in place of pumps costing much more . . . for handling chemical solutions, fuel oils, lube oils, hydraulic liquids, etc.

The "Hydrex" needs no costly speed reducer—can be direct-connected up to 1800 RPM. Extreme simplicity allows heavier construction, easier installation and maintenance, less downtime, longer life.

Models available to pump liquids from 32 SSU to 250,000 SSU, at 1 to 350 GPM, up to 500 PSI. Call your local Sier-Bath Pump Representative . . . write to *Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Blvd., North Bergen, N. J.*

Sier-Bath ROTARY PUMPS



50th Anniversary — Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings — Member A.G.M.A.

New Equipment . . .

are reduced to simple, quick routines. All dimensions conform to standards of ISA Recommended Practices (P.R. 16.1—tentative). Fischer & Porter Co.

Circle E15 green card, last page

Heat Conducting Cement Transfers Heat to Vessel

Thermon T-3 is a fine grained, relatively slow drying heat conducting cement. Its purpose is to fill the voids between a vessel surface and an external embossed type plate coil installed for the purpose of either heating or cooling the contents of the vessel. The use of Thermon T-3, eliminates heat transfer from the plate coil to the vessel wall through an air gap by providing a path of solid heat conducting material. This greatly increases the efficiency of the plate coil system and results in increased production at reduced cost. Thermon Manufacturing Co.

Circle E16 green card, last page

Maintenance Bulletin Tells How to Clean Tanks

"Storage Tank Cleaning and Paint Stripping" is the title of the second refinery maintenance bulletin, just published. The illustrated bulletin discusses first,

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the cleaning of storage tank interiors by spray application of detergent solution to remove medium heavy soils, or by fogging with solvent followed by spraying and soaking to remove heavier soils. Cleaning of exterior tank surfaces with solvent or alkaline detergent is then discussed, and is followed by a section on paint stripping. The method recommended is application of solution through a perforated pipe "rake," which may be placed and raised or lowered as desired to insure thorough paint removal. Oakite Products, Inc.

Circle E17 green card, last page

Portable Air Tools Have Noiseless Exhaust

The introduction of a new series of portable tools with noiseless, blastless exhaust has been announced. Initial models now available are light and medium duty types of drills, screwdrivers and tappers. Nearly all of these air tools will eventually incorporate noiseless exhaust.

Heretofore, most air tools have been so designed that air moves generally in a forward direction from the inlet to the exhaust port, and escaping air moves only a short distance from the cylinder before being vented.

In Aro's new tools, the exhaust air is now routed back through a system roughly parallel to the inlet system, and escapes at a point adjacent to the air inlet. A porous bronze diffuser, located at the outlet, deadens any remaining exhaust noise and dissipates the escaping air evenly in all directions. The Aro Equipment Corp.

Circle E18 green card, last page

Heavy Duty Hand Saw Cuts Mild Steel and Aluminum

The KS-3AM Panel Master Saw is the answer to the demand for quick, simple and low cost cutting of thin panels. The saw "walks" through mild steel up to 16 gage; "zips" through aluminum up to three-sixteenths inch, and fairly "flies" through such soft rigid materials as Masonite and plywood, to its full three-eighths inch depth of cutting capacity.

The saw cuts quickly and cleanly. The finished cut resembles a milled edge. There is no buckling or warping of the sheet on either side of the cut and there is appreciatively little or no "flash." With the Kett saw no starting holes are required . . . simply "plunge" into the surface and cut. The Kett Tool Co.

Circle E19 green card, last page

New Equipment . . .

Electronic Unit Detects Danger, Warns By Phone

Now introduced is a new unit capable of electronically and automatically detecting a wide variety of abnormal conditions and of alerting a designated person by telephone.

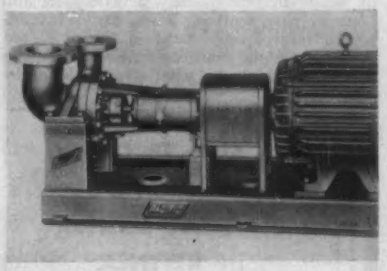
The device, known as the "Electronic Sentry," is designed to provide an instant, automatic alert to personnel responsible when the possibility of danger due to fire, pressure, water levels, temperature, theft or any other hazardous conditions exist.

When an alert condition occurs, a primary detecting device such as a thermostat, a pressure control, a capacitive burglar detector, a water level measuring gauge, or any control capable of closing a switching circuit, causes the Electronic Sentry to go into action.

The Electronic Sentry will then (1) connect itself across the telephone line. (2) dial a predetermined telephone number electronically, and (3) by means of a prerecorded message, inform the person who answers of the nature of the trouble. The warning message is transmitted repeatedly so that if it is not understood the first time, repetition will insure comprehension. At the end of a predetermined time, the unit will disconnect momentarily from the telephone line. If the condition that caused the warning is not corrected, however, the Electronic Sentry will again dial the number and repeat the warning message until the warning message is acted upon.

The unit, of compact and rugged construction, is 8 inches wide, 8¼ inches high, 11¼ inches long and weight 17½ pounds. It consists of the primary detection device, specially designed record player, electronic relay amplifier and audio amplifier. Automatic Electric Co.

Circle E20 green card, last page



Interchangeable Parts Featured in Pump Line

Twenty important parts are interchangeable within four size groups and 21 pump sizes. The new single stage pumps feature a double wearing ring impeller, angular contact thrust bearings, a mechanical seal or conventional packing. The rotating element—shaft, shaft sleeve, impeller, wearing rings, head, packing gland, bearings and housings—form a completely unitized assembly. This simplified design provides rapid dismantling and reassembly—reduces maintenance costs.

Developed for economical transfer of hydrocarbons, chemical solutions, acids, and condensates, the SVA pump has a

HAS THE ANSWER TO YOUR FLEXIBLE TUBING PROBLEMS

It's "Flexineering" — the technical help of Penflex engineers on your specific design, application and installation *plus* the "know how" to supply just the right flexible tubing for your need.

If you want to convey air, water, steam, gases, volatiles; granular, abrasive or light solid materials . . . or require flexible connections that "give" with vibration, expansion, contraction, come to Penflex. Its complete line of bronze, galvanized and stainless steel, corrugated and interlocked tubing is rugged . . . safe at high pressures and temperatures, free from metal fatigue. All types, all sizes in ⅛" to 24" I.D.

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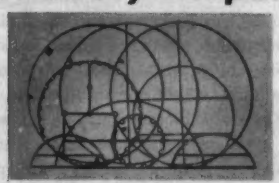
For Every Purpose



HEAT EXCHANGER GASKETS

Made in any size or shape needed in double jacket type. Also cut from solid metal or sheet packing. Write for Bulletin 564.

CORRUGATED METAL GASKETS

Plain or jacketed type. Made of ingot iron, aluminum, stainless steel, copper, brass, nickel and monel in all sizes and shapes. Write for Bulletin 565.

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New Equipment . . .

capacity of 15 to 1600 GPH at a working pressure of 500 psig, a differential head of 700 feet, speeds of 3600 rpm and temperatures to 300 F.

Radially split case; dynamically and hydraulically balanced impellers; one piece head and packing box; precision fit shaft and sleeve, and wide range of materials are additional features of the new line of SVA pumps. Pacific Pumps, Inc.

Circle E21 green card, last page

Plastic Coated Aluminum Pipe Resists Corrosion

A new plastic coated aluminum pipe suitable for use under highly corrosive conditions such as salt water disposal lines is now being manufactured.

Primarily designed for the oil industry, the aluminum pipe is coated with a new baked polyurethane coating. The coating has efficient flow characteristics and gives excellent resistance to salt water, acids, caustic fluids, crude oil and other corrosive agents. Its superior bonding qualities and high degree of flexibility provide long service life.

The new product offers all the advantages of aluminum pipe in weight, permitting low installation costs for above-ground piping systems.

The new TK-33 coated aluminum pipe is available in a complete range of sizes in schedules 5, 10 and 40. Kaiser Aluminum & Chemical Sales, Inc.

Circle E22 green card, last page

Bond New Concrete To Old With Epoxy Adhesive

Announcing the development of a new modified epoxy adhesive, for use in bonding new concrete to old concrete.

This material, designated as concrete adhesive 192-34, now solves many difficult concrete patching jobs such as the leveling of floors that are badly deteriorated and contain ruts, gullies, holes, etc. This adhesive assures tight bond of the new concrete to the old concrete. Entire floor areas can be resurfaced. Other uses include the repairing of broken corners on concrete bases, curbings, islands, etc., avoiding the necessity of complete replacement.

The adhesive has a solids content of 90 percent by weight, applies at a thickness of 6 mils, with a coverage of 200 square feet per gallon. Carboline Co.

Circle E23 green card, last page

Digest Describes Metal With Unusual Properties

The "Ductile Iron Digest" (18 pages, illustrated), describes a new metal as strong as carbon steel with a tensile strength up to 200,000 psi. It can literally be twisted and bent without cracking and has as much as 30 percent elongation. Charpy impact values range from 15-115 . . . more like steel than iron. The fully illustrated booklet with 24 case records

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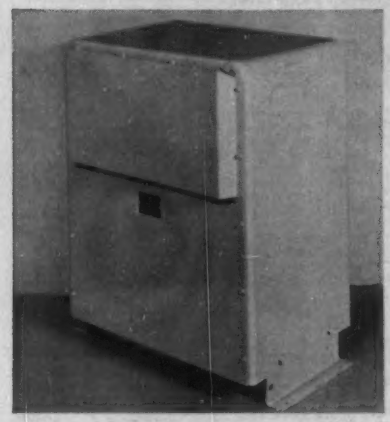
shows how strength and toughness can be cast in tiny levers and huge engine frames. Large gears can be made inexpensively, then flame hardened to the temperature of tool steel. The International Nickel Co., Inc.

Circle E24 green card, last page

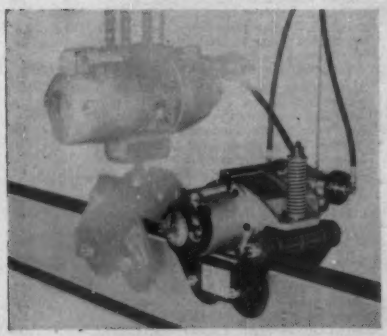


Weather Shields Convert Transformer for Outdoors

Dry-type distribution transformers (DS-3 and DT-3) can be used outdoors by simply adding a pair of weather shields to each unit. Shields are available for all units rated 300 kva and below in the 600-volt class.

These shields—baffles of heavy gage steel to keep out driving rain or snow—can be purchased separately and installed in the field by removing only four panel bolts, and replacing them with the shields in place. Westinghouse Electric Corp.

Circle E25 green card, last page



One Man Can Raise, Lower And Move Two Ton Loads

Now, one man can raise, lower or move loads up to two tons with positive control. It's all done with a new powered hoist trolley.

Powered by an axial-piston type air motor, it exerts 250-pound drawbar pull on a beam through a rugged spring-loaded neoprene drive wheel (see photo). It will pull a two-ton load at 70 feet per minute. Speed can be varied from a slow creep to full speed of 150 feet per minute.

A single one-hand control for hoist and tractor is available in two types. Both types control raising and lowering the load by hoist, and moving the load. Both leave the operator one hand free to guide the load. Gardner-Denver Co.

Circle E26 green card, last page

Nitrogen-Propelled Dry Chemicals Fight Fires

A compact, low-priced portable fire-fighting unit, represents the first completely-successful application of dry chemicals to control major fires, according to its makers.

Effectiveness is gained through use of the invertible sphere to store 1,500 pounds of nitrogen-propelled dry chemicals. While the unit is idle, outlets are at the top, above powder level, eliminating any possibility of clogging. In use, the sphere is automatically inverted to working position.

After use, it can be completely cleaned and ready for the next usage in a matter of seconds. The sphere is simply returned to the original position, and the remaining nitrogen blows lines clean. Fire Boss, Inc.

Circle E27 green card, last page

Folder Tells Flux Effects In Submerged Arc Welding

A new 4-page folder contains information of value to welders, fabricators and welding engineers using submerged arc welding on stainless or low alloy steels. This booklet pictorially demonstrates the effect of varying welding speed, current, voltage or flux burden, and discusses fringe influences of the various observable results. Text also lists color coding of Acrosite fluxes for submerged arc welding, the alloys to be welded with each, and the approximate composition of the weld deposit produced. Arcos Corp.

Circle E28 green card, last page

Tear Sheets—Reprints

Handling costs compel Gulf Publishing Company to make a charge of 25 cents per article for all TEAR SHEETS ordered. Such tear sheets will be sent, when available, if cash (or company requisitions) accompany's the order.

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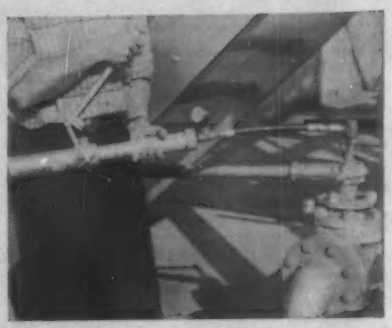

High-Pressure Handgun Lubricates Plug Valves

A new high-pressure hydraulic handgun specially designed for plug valve lubrication is now offered.

Lighter and more rugged than conventional guns, the new "400-C" is self-priming and can be used in any position.

Because of the extra-high pressure this gun exerts, the hose and coupler can be locked to the buttonhead fitting in the valve shank. The pressure may be relieved by a turn of the by-pass valve on the gun—readily permitting separation of the buttonhead coupler and fitting.

Other protective features include:

1. A relief fitting on the hydraulic system to guard against injury to the gun if the operator continues to pump after the gun is empty.

2. A 15,000-psi gage indicating the point at which sufficient lubricant pressure has been developed in the valve—signaling this by a sudden drop in pressure reading. The gage also indicates valve adjustment and other services required—and has a "recalibrator" screw providing positive and easy corrections in case it is knocked out of adjustment by rough handling. Rockwell Manufacturing Co.

Circle E29 green card, last page

Metal Cleaning Tools Use High Speed Cutters

A new bulletin describes the maintenance savings and ease of maintenance operations that can be accomplished through the use of the company's cleaning tools.

These tools are electrically or pneumatically operated. They remove paint, scale, rust and other accumulations from steel and all hard surfaces by the action of two cutter bundles. The cleaning or chipping action of the tool is supplied by a large number of cutters loose-pinioned around the rotating head. The head revolves at high speed, throwing the cutters by centrifugal force against the surface being cleaned. There is an adjustable depth shoe which can be set to limit the impact of the cutters so that there will be just enough to take off the foreign matter without biting into and damaging the permanent surface. Aurand Mfg. & Equip. Co.

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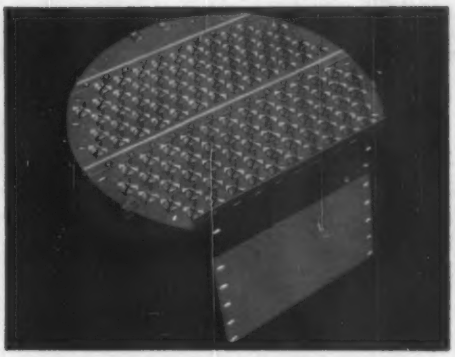

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